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# INVENTORY OF LAKE MICHIGAN RESEARCH PROJECTS 1984-1987

Compiled by Nancy Peterson Holm



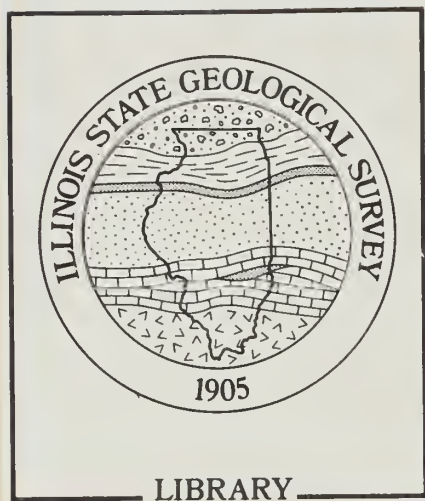
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Inventory of Lake Michigan research projects 1984-1987 / compiled  
by Nancy Peterson Holm. — Champaign, IL, Illinois State Geolog-  
ical Survey, 1987.

423 p. — 28 cm. — (Environmental geology notes ; 121)

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*Printed by authority of the State of Illinois/1987/650*

# **INVENTORY OF LAKE MICHIGAN RESEARCH PROJECTS 1984–1987**

**Compiled by Nancy Peterson Holm**

**Lake Michigan Program  
Illinois State Geological Survey  
Champaign, Illinois**

**ILLINOIS STATE GEOLOGICAL SURVEY  
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**1987  
ENVIRONMENTAL GEOLOGY NOTES 121**

**Illinois Department of Energy and Natural Resources  
STATE GEOLOGICAL SURVEY DIVISION**



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**ILL. STATE GEOLOGICAL SURVEY**

## **ACKNOWLEDGEMENTS**

Funding for this project was provided by The Joyce Foundation and the Illinois Department of Energy and Natural Resources. I wish to thank Steve Jann, Beth Morgan, Joanne Klitzing and Kathy Cooley for their work on final preparation of this inventory. I also wish to thank Charles Collinson (ISGS), Robert Gorden (INHS), Donald Gatz (ISWS), and Peter Lamb (ISWS) for their input on the initial three-Survey Lake Michigan Scoping Study sponsored by the Illinois Department of Energy and Natural Resources, Board of Natural Resources and Conservation.



## INTRODUCTION

This inventory was begun in 1984 as part of the Lake Michigan Scoping Study jointly undertaken by the three Illinois Scientific Surveys and sponsored by the Illinois Department of Energy and Natural Resources, Board of Natural Resources and Conservation. The purpose of the scoping study was to provide a basis for developing prioritized coordinated programs as well as a long-term research agenda for the Illinois Scientific Surveys and other state agencies. An essential part of that study was to define what research was being conducted on the lake and, therefore, a review was conducted to assess the existing research programs of various agencies and universities working on Lake Michigan. Funding from the Joyce Foundation has allowed the inventory to be updated and published this year. It is hoped that this inventory will prove useful to Great Lakes researchers, environmental managers, and citizen groups.

The information on current research projects was obtained by letter requests and telephone conversations with over 300 individuals from September 1984 through June 1987, from conferences attended, and from recent Sea Grant proposal volumes. The information received was entered into a computerized database (using the TERMS program on a Prime 9955 computer system) allowing sorting by keywords, main investigators, their agencies, sponsoring organizations, etc.

This inventory focuses on research projects and does not include strictly monitoring or surveillance projects. Projects completed in 1984 and 1985 are included with ones from 1986 and ongoing because information from the earlier projects may not yet be available in the literature.

The listing is alphabetized by the last name of the main investigator. Each project listing includes main investigators, their agencies, project title, starting and completion dates (if known), area of the lake studied, keywords, and project description (if available). Indexes are given for subject (keywords), area of lake studied (if known more specifically than just Lake Michigan), and main investigators. In the subject index, when two words are joined by an underscore ("\_"), this indicates both words are found in the keywords but not necessarily next to each other. The two words are associated in the index to more specifically define the subject. For example, CYCLING\_NUTRIENTS gives the reference numbers for projects on nutrient cycling, whereas CYCLING\_ORGANICS gives the reference numbers for projects on the cycling of organics. If specific subjects have only a few references, more information can be found by looking under a broader subject which includes it. To direct the user to other appropriate words, certain subjects are cross-referenced with the symbol "SA:" meaning "see also," e.g., CARBARYL (SA: pesticides); in other cases, the user is referred by the symbol "S:" meaning "see" to a different word in the index which has been used in place of another word, e.g., MARSHES (S: wetlands).

Any omissions or errors in project information are inadvertent. The Lake Michigan Program would appreciate being notified of any additions or corrections.



Ref. no. 1

ABSHER, J.; COLLINS, J.

Georgia - University of Georgia, Athens

Dept. of Recreation and Leisure Studies;

Illinois - University of Illinois, Champaign-Urbana

Illinois/Indiana Sea Grant Program

SPECIALIZATION IN RELATION TO THE MANAGEMENT OF THE  
SOUTHERN LAKE MICHIGAN SPORTFISHERY: LICENSED ANGLERS

Starting date: 4/01/1984

Completion date: 6/01/1986

Project no: R/C-01

Sponsor: Illinois/Indiana Sea Grant Program

AREA: Southern Lake Michigan; Illinois; Indiana

KEYWORDS:

recreation, fish, economics, pollution, management,  
sport fishing, sociology, survey

DESCRIPTION:

Objectives:

To (1) develop and evaluate an expanded fishing  
specialization model for southern Lake Michigan;  
(2) examine relationships among subgroups of anglers  
knowledge, and preference data, and management  
variables for each state; (3) estimate the extent  
pollution is concern among sportfishermen; (4) identify  
implications for fisheries development and management.

Methods:

Mail questionnaire to resident and non-resident  
fishing licensees in Illinois and Indiana.

Benefits:

Provide previously unknown information about southern  
Lake Michigan anglers and may complement on-going  
creel census in each state.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 2

AMUNDSON, C.; KAYES, T.  
Wisconsin - University of Wisconsin-Madison  
Food Science Dept.

## ASSESSMENT OF DIETARY AMINO ACID REQUIREMENTS OF A REPRESENTATIVE GREAT LAKES FISH

Starting date: 9/01/1980  
Completion date: 8/31/1984  
Project no: R/AQ-09  
Sponsor: University of Wisconsin Sea Grant Institute

AREA: Laboratory

### KEYWORDS:

aquaculture, nutrition, biology, rainbow trout, diet, food,  
biochemistry, protein, amino acids, fish

### DESCRIPTION:

#### Objectives:

To determine the amino acid (AA) requirements of rainbow trout and develop optimal diets that substitute high-protein feedstuffs for marine fishmeal. Specifically: (1) develop an AA test diet that promotes good growth at a standard environmental temperature of 15 C, and assess if certain biochemical indicators can be used to evaluate the AA and protein needs of fish; (2) determine ARG and MET needs of trout under crowded, high-NH<sub>3</sub> vs. uncrowded, low-NH<sub>3</sub> conditions at 10 & 15 C set.

#### Rationale:

Because marine fishmeal is so expensive, feed is one of the biggest costs in fish farming. The development of more efficient, cost-effective feeds for trout depends on exact information on the AA requirements of rainbow trout under several environmental conditions.

#### Benefits:

Trout and salmon feeds constitute a third of the fish feed now made in the U.S. The use of local protein sources would greatly reduce feed costs in the Great Lakes region, and nationally a mere 5% decrease in feed costs would reduce trout production cost \$1.3 million to \$1.7 million a year. Such knowledge could also be applied to salmon and other coldwater fish.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 3

AMUNDSON, C.; KAYES, T.

Wisconsin - University of Wisconsin-Madison  
Food Science Dept.

GENETIC MANIPULATION OF GROWTH AND PRODUCTION OF SELECTED  
GREAT LAKES COOLWATER FISHES

Starting date: 3/01/1985

Completion date: 8/31/1989

Project no: R/AQ-14

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Laboratory

KEYWORDS:

aquaculture, biology, genetics, walleye, sauger, fish,  
yellow perch, hybridization, growth, diet

DESCRIPTION:

Objectives:

In walleye, sauger and yellow perch, to: (1) evaluate selected physical/chemical methods of inducing polyploidy; (2) examine methods of inducing gynogenesis and androgenesis; (3) make all possible hybrid crosses; and (4) compare polyploid, gynogenetic, androgenetic and hybrid fishes with normal diploid purebreds, in terms of viability, production characteristics (e.g. survival, feed acceptance, growth, reproductive status), and fillet yield and organoleptic qualities.

Methodology:

Using thermal shock, hydrostatic pressure or chemical treatment of fertilized eggs and/or radiation of gametes to induce polyploidy, gynogenesis and androgenesis; using flow cytometry and chromosomal spreads to assess ploidy and karyotype.

Rationale:

Genetic manipulations could help resolve the following problems associated with coolwater fish culture: (1) the difficulty of habituating fish to artificial feeds; (2) poor adaptability of most species to intensive culture conditions; (3) low growth potential of some species; and (4) reduced growth and carcass yield associated with sexual maturation.

Accomplishments:

During the first 10 months of this project, we (1) developed experimental egg incubation units suitable for culturing thermally shocked walleye and perch eggs; (2) adapted the technique of chromosome spread analysis to determine ploidy of walleye and perch embryos; (3) determined maximum sublethal heat shock treatment regimes for perch

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

and walleye eggs; (4) induced triploidy in purebred perch and perch x walleye hybrid embryos; and (5) raised 500 walleyes from thermally shocked eggs to a size of 100-150 mm (4-6") total length. Many of these walleyes are probably triploid.

### Benefits:

This project will provide fish culturists, managers and researchers with basic information on the genetic characteristics of coolwater fishes and genetic manipulations applicable to their culture to enhance the feasibility of intensive coolwater fish culture and provide culturists and managers with improved fish strains. This could lead to decreased production costs for public hatcheries, increased potential for commercial culture and improved fisheries in the Great Lakes region.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 4

AMUNDSON, C.; KIM, K.I.

Wisconsin - University of Wisconsin-Madison  
Food Science Dept.

COMPARATIVE STUDIES ON ENERGY METABOLISM IN  
SELECTED FISHES

Starting date: 9/01/1984

Completion date: 8/31/1986

Project no:

Sponsor: U.S.D.A. Special Grants Program

AREA: Laboratory

KEYWORDS:

biology, biochemistry, fish, energy, metabolism,  
physiology

DESCRIPTION:



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 5

AMUNDSON, C.; KIM, K.I.

Wisconsin - University of Wisconsin-Madison  
Food Science Dept.

AMINO ACID OXIDATION AND ITS APPLICATION TO  
DIET FORMULATION IN RAINBOW TROUT AS A  
MODEL TELEOST

Starting date: 10/01/1982

Completion date: 9/01/1984

Project no:

Sponsor: U.S.D.A. Hatch funds

AREA: Laboratory

KEYWORDS:

biology, biochemistry, aquaculture, fish, diet,  
trout, amino acids

DESCRIPTION:



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 6

AMUNDSON, C.; KIM, K.I.; KAYES, T.

Wisconsin - University of Wisconsin-Madison  
Food Science Dept.

COMPARATIVE STUDIES ON THE REQUIREMENTS OF SELECTED  
GREAT LAKES FISHES FOR PROTEIN AND (KEY) AMINO ACIDS

Starting date: 9/01/1984

Completion date: 8/31/1988

Project no: R/AQ-13

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Laboratory

KEYWORDS:

aquaculture, biology, rainbow trout, fish,  
coho salmon, catfish, diet, amino acids,  
nutrition, protein

DESCRIPTION:

Objectives:

To compare the dietary protein and amino acid requirements of selected commercially important Great Lakes fishes by (1) completing ongoing research on the amino acid requirements of rainbow trout (for histidine, threonine, leucine, isoleucine, and valine) and (2) comparing the protein arginine, methionine and lysine requirements of rainbow trout, coho salmon, channel catfish, and other fishes.

Methodology:

Conventional feeding trials will be conducted using purified diets at temperatures optimal for growth. Endpoints examined will be growth, feed utilization and nitrogen retention.

Rationale:

Large variations in the nutritional requirements of fishes have been reported. Our comparative studies should (1) add continuity to fish nutrition research and (2) aid in standardization of feed formulation.

Accomplishments:

We have determined the protein, arginine, lysine, methionine, cystine, tryptophan, phenylalanine and tyrosine requirements of rainbow trout. Our work on protein-energy relationships presents the possibility of lowering the dietary requirements for good-quality protein to 24 percent, provided that appropriate energy sources are present at optimal levels. Four manuscripts have been prepared and submitted for publication.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 7

ANDERSON, M.; TAYLOR, R.; CHERKAUER, D.

Wisconsin - University of Wisconsin-Madison  
Geology and Geophysics Dept.;

Wisconsin - University of Wisconsin-Milwaukee  
Geological and Geophysical Sciences Dept.

GEOPHYSICAL ASSESSMENT OF THE HYDRAULIC CONNECTION  
BETWEEN LAKE MICHIGAN AND THE GROUNDWATER AQUIFERS  
ON ITS WESTERN BOUNDARY

Starting date: 9/01/1979

Completion date: 8/31/1984

Project no: R/MN-01

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Wisconsin waters; Western Lake Michigan; Green Bay

KEYWORDS:

groundwater, seismic surveys, electrical resistivity, physical,  
geology, hydrology, water budget, aquifer, geophysical, sediments

DESCRIPTION:

Objectives:

To develop a method -- combining measurement  
of seismic and electrical resistivity properties  
of lakebed sediments with offshore core  
collection and onshore hydrogeologic work --  
to determine, in a rapid and accurate  
manner, the hydraulic properties of lakebed  
sediments over large areas. To use this  
method to estimate the magnitude of the  
hydraulic connection between Lake Michigan  
and the aquifers on its western boundary.

Rationale:

This work will allow the estimation of the amount  
of groundwater that discharges into Lake Michigan  
for aquifers along its western shoreline, and the  
assessment of how much groundwater could be induced  
to flow from Lake Michigan into areas of heavy or  
potentially heavy groundwater pumpage.

Benefits:

Beyond questions of water supply, this project will  
answer questions related to contaminants and waste disposal  
such as: where contamination of the lake is possible from  
surface waste disposal and contaminated groundwater, and  
where groundwater influxes to the lake may be flushing  
contaminants from lake sediments into the lake.

This project is continuing as project no. R/MW-35.

For further description, see Taylor et al. (ref no. 295).

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 8

ANDREN, A.

Wisconsin - University of Wisconsin-Madison  
Water Chemistry Laboratory

THE BEHAVIOR OF PCBS IN LAKE MICHIGAN

Starting date: 1982

Completion date: 1984

Project no:

Sponsor: U.S. EPA

AREA: Lake Michigan

KEYWORDS:

chemistry, organics, toxics, PCBs, behavior,  
flux, air-water interface, water quality,  
contaminants, atmospheric transport

DESCRIPTION:

Objectives:

To evaluate the atmospheric transport of PCBs across  
the air/water interface of Lake Michigan.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 9

ANDREN, A.; ARMSTRONG, D.

Wisconsin - University of Wisconsin-Madison  
Water Chemistry Laboratory

## FATE ASSESSMENT OF HYDROPHOBIC ORGANIC CHEMICALS IN AQUEOUS ENVIRONMENTS

Starting date: 9/01/1979

Completion date: 8/31/1984

Project no: R/MW-21

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Green Bay; Fox River; Lake Michigan

### KEYWORDS:

model, chemistry, pollutants, analytical methods,  
water quality, monitoring, toxics, aqueous solubility,  
vapor pressure, octanol-water partition coefficients,  
EXAMS, organics, fate, contaminants

### DESCRIPTION:

#### Objectives:

- (1) Determine if present assessment procedures can be used to predict the fate of selected chemicals in aqueous systems like the lower Fox River/Green Bay;
- (2) measure, predict via structure-activity relations and couple basic physico-chemical parameters like solubility, vapor pressures, absorption coefficients, and degradation, photolysis and volatilization rates;
- (3) incorporate these parameters in existing models designed to give pollutant behavior profiles for a variety of aqueous systems.

#### Rationale:

Pollution control agencies, managers of contaminated fisheries, fishermen and the public need information about the fate of contaminants in aquatic ecosystems to determine the long-term outlook for various contaminants in fish.

#### Accomplishments:

Developed accurate and precise techniques for measuring aqueous solubility, vapor pressures and octanol/water partition coefficients. Acted as consultants to N.B.S.; the technique most likely will be used as reference methods. Evaluated E.X.A.M.S. with input from our property estimation techniques; all are on the computer. Asked by regulatory agents to help them with fate assessments for toxic chemicals.

#### Benefits:

When combined with assessment applications, the property measurement techniques being developed will

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

help state and federal agencies and researchers predict the behavior of hazardous chemicals in the environment without expensive sampling and monitoring programs. The models should prove very useful in developing pollutant monitoring strategies.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 10

ANDREN, A.; ARMSTRONG, D.

Wisconsin - University of Wisconsin-Madison  
Water Chemistry Laboratory

## FATE ASSESSMENT OF ORGANIC CHEMICALS IN AQUEOUS ENVIRONMENTS

Starting date: 9/01/1984

Completion date: 8/31/1988

Project no: R/MW-31

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Laboratory

### KEYWORDS:

model, chemistry, analytical methods,  
PCBs, furans, dioxins, vapor pressure,  
PBBs, octanol-water partition coefficients,  
solubility, toxics, water quality, fate, organics

### DESCRIPTION:

#### Objectives:

To (1) improve and evaluate present assessment procedures designed to predict fate of halogenated aromatic hydrocarbons (HAHs) in lakes, rivers, precipitation, and groundwater; (2) determine important physico-chemical properties of these compounds; (3) develop and evaluate estimation methods for these properties; (4) identify and compile model input parameters from a variety of data bases; (5) interface computer models for property estimation and fate assessment; (6) generate and "validate" environmental behavior profiles for high-risk HAHs.

#### Methodology:

Use of "generating column methods" for the determination of aqueous solubilities, octanol-water partition coefficients and vapor pressures. Development of a variety of computer models to interface property estimation and fate assessment schemes.

#### Rationale:

Environmental assessment models for toxic substances require a variety of physico-chemical input parameters. The influence of dissolved organic matter, colloids and particles on these properties is unknown. A variety of property estimation techniques for HAHs must be pursued to verify and interface the data thus generated with present and future assessment models.

#### Accomplishments:

(1) Developed accurate and precise techniques for measuring aqueous solubility(s), vapor pressures (V.P.), octanol-

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

water partition coefficients (KOW) and Henry's Law constants (H) for several PCBs, PBBs, dioxins, and furans; (2) compiled and developed theoretical procedures to estimate the above properties plus molar volumes, molecular diffusivities, molecular surface areas and polaris abilities; (3) all estimation techniques have been computerized and interfaced several assessment models; (4) project personnel have acted as consultants to NBS, EPA and Wisconsin DNR.



# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 11

ANDREN, A.; LIGHTFOOT, E.N.; GREEN, T.  
Wisconsin - University of Wisconsin-Madison  
Water Chemistry Laboratory;  
Wisconsin - University of Wisconsin-Madison  
Chemical Engineering Dept.;  
Wisconsin - University of Wisconsin-Madison  
Civil and Environmental Engineering Dept.

## ATMOSPHERIC CONCENTRATIONS AND TRANSPORT OF ORGANIC CONTAMINANTS ACROSS THE AIR/WATER INTERFACE IN THE UPPER GREAT LAKES

Starting date: 9/01/1982  
Completion date: 8/31/1986  
Project no: R/MW-28  
Sponsor: University of Wisconsin Sea Grant Institute

AREA: Upper Great Lakes; Lake Michigan; Lake Superior; Lake  
Huron

### KEYWORDS:

PCBs, PAHs, chemistry, toxics, organics, toxaphene,  
hydrophobic, air-water interface, atmospheric, flux,  
precipitation, model, transport, contaminants, sampling,  
vapor pressure, organochlorine pesticides,  
analytical methods

### DESCRIPTION:

#### Objectives:

To (1) measure PCB, PAH, toxaphene, and other hydrophobic organic components in air over Lake Michigan, (2) measure time trends in pollutant concentrations in precipitation and air at a stationary site, (3) improve our understanding of the transfer of sparingly soluble organic contaminants across the air/water boundary of large bodies of water.

#### Methodology:

Hi-volume air sampling with vapor traps, sampling tied into wind speed and atmospheric stability, analysis performed via capillary column GC. Single congener analysis for fractionation study. Models will be computerized.

#### Rationale:

No time-trend analyses of PCB, PAH, and other contaminants in air exist, such data is needed to assess pollution abatement programs. New models on the transport of vapor across air/water interfaces must be developed and examined, taking into account recent developments in hydrodynamics and the atmospheric flux of these substances in the Upper Great Lakes.



## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

### Accomplishments:

Developed a new sampling protocol that ties air sampling in with such meteorological factors as wind direction and boundary layer stability. Perfected the technique for measuring PCB and PAH in both vapor and particulate phases. Developed a technique for measuring vapor absorption onto micron-sized particles and a first-order model that analyzes the role of Langmuir circulation in liquid-phased transport of vapors. Data are now being analyzed. Specifically, achieved an estimate for the exchange of PCB across the air/water interface of Lake Michigan.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 12

ARMSTRONG, D.

Wisconsin - University of Wisconsin-Madison  
Water Chemistry Laboratory

## STATUS REPORTS ON PRIORITY POLLUTANTS IN THE GREAT LAKES

Starting date: 9/01/1982

Completion date: 8/31/1984

Project no: R/MW-29

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Great Lakes Basin

### KEYWORDS:

PCBs, toxics, organics, chemistry, toxaphene, water quality, dioxins, chlorobenzenes, chlorophenols, contaminants, sources, human health, fate, review, pollutants, organochlorine pesticides

### DESCRIPTION:

#### Objectives:

To prepare a series of status reports on priority pollutants in the Great Lakes Basin. Specifically: (1): conduct a thorough review of all information about the Environmental Protection Agency's 129 priority pollutants; (2) analyze and evaluate the information according to industrial sources, occurrence in the Great Lakes, health effects, environmental fate and analytical reliability of data; (3) develop status reports for each of about 10 chemical subcategories and summary report.

#### Rationale:

Information on ocean and Great Lakes contaminants is a high national priority, as evidenced by passage of the Ocean Marine Act. Agencies dealing with contaminant problems and the public as well want comprehensive information about pollutants in the Great Lakes, but such information is not readily available.

#### Accomplishments:

Status report has been published on toxaphene - "Toxaphene: Status in the Great Lakes" by J. Sullivan and D. Armstrong, 1985. Contributed to University of Wisconsin Sea Grant Advisory publication, "Dioxin: A Cause for Concern". Prepared report on chlorinated benzenes and another on chlorophenols in the Great Lakes.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 13

ARMSTRONG, D.

Wisconsin - University of Wisconsin-Madison  
Water Chemistry Laboratory

## TRANSPORT AND FRACTIONATION OF HYDROPHOBIC COMPOUNDS BY SUSPENDED PARTICULATE MATTER IN LAKE MICHIGAN

Starting date: 9/01/1984

Completion date: 8/31/1988

Project no: R/MW-33

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Southern Lake Michigan

### KEYWORDS:

chemistry, pollutants, PCBs, transport,  
sediments, water quality, organics, particulates,  
fate, flux, sediment traps, residence time, toxics

### DESCRIPTION:

#### Objectives:

To characterize the particle-mediated transport and fate of hydrophobic organic compounds in Lake Michigan. Specifically, to determine: (1) dissolved and particulate concentrations; (2) settling fluxes; (3) properties of HOCs and particles and the other factors controlling their associations; and (4) the relative roles of HOC properties, particle characteristics and particle fluxes in controlling transport rates of HOCs.

#### Methodology:

Depth-segregated time series sampling of suspended and settling particulates; size fractionation of particulate matter; analysis of hydrophobic organic compounds using capillary column gas chromatography.

#### Rationale:

Particulate matter plays a major role in controlling the transport and fate of hydrophobic organic compounds, but information on particle- and compound-specific interactions is limited. This information is needed to predict fluxes and residence times as influenced by in-lake conditions.

#### Accomplishments:

Work on field and laboratory methodology and the first year of field sampling are completed for PCBs. Samples were collected from sediment traps. Suspended particulate matter and dissolved concentrations in the lake water column were also collected. Sample processing and analysis is partially completed. Second-year sampling is planned to begin in the spring of 1987.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 14

ARMSTRONG, D.; ANDREN, A.

Wisconsin - University of Wisconsin-Madison  
Water Chemistry Laboratory

ROLE OF PARTICULATE MATTER IN CONTROLLING  
MICROCONTAMINANT BEHAVIOR IN LAKE MICHIGAN

Starting date: 9/01/1983

Completion date: 8/31/1984

Project no: R/MW-24

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Southern Lake Michigan

KEYWORDS:

toxics, trace metals, chemistry, biology, transport, fate,  
zooplankton, phytoplankton, cycling, nutrients, inorganics,  
sedimentation, water quality, particulates, sediment traps

DESCRIPTION:

Objectives:

To characterize the particle-mediated processes and mechanisms governing toxic element transport in the water column and to bottom sediments: (1) characterize suspended particulate matter into functionally different types and sizes; (2) determine the associations of specific toxic elements with these different particle types and sizes; (3) assess the behavior of particle species in the water column and the major factors controlling particle formation, behavior and fate.

Accomplishments:

Several papers presented and manuscripts in prep.  
This project is continuing as project no. R/MW-37.  
For further description, see Armstrong, D.; Andren, A.  
(ref. no. 15) on the following page.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 15

ARMSTRONG, D.; ANDREN, A.

Wisconsin - University of Wisconsin-Madison  
Water Chemistry Laboratory

## ROLE OF PARTICLE-MEDIATED PROCESSES IN CONTROLLING METALS AND SILICA IN LAKE MICHIGAN

Starting date: 9/01/1984

Completion date: 8/31/1988

Project no: R/MW-37

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Southern Lake Michigan

### KEYWORDS:

trace metals, chemistry, transport, cycling, particulates, sedimentation, phytoplankton, zooplankton, sediment traps, silica, phosphorus, water quality, inorganics, nutrients, organic carbon, calcium carbonate, mixing, chlorophyll, stratification, thermocline, particle size, regeneration, flux, lead-210, cadmium, chromium, copper, zinc

### DESCRIPTION:

#### Objectives:

To determine the role of particle production and removal processes in controlling the levels of key elements in Lake Michigan by: (1) characterizing and quantifying the major particle production and removal processes in Lake Michigan; (2) determining the particle-specific interactions controlling the concentrations and the fluxes of trace metals; and (3) determining the factors and processes controlling the particle-mediated removal of Si and P from Lake Michigan.

#### Methodology:

Sediment traps, pumping/sieving/centrifugation, niskin filtration, neutron activation, atomic adsorption, plasma emission, scanning electron microscopy, X-ray fluorescence, electron microprobe, light microscopy, and chemical dissolution.

#### Rationale:

Suspended particulate matter exerts a major control on concentrations of metals and silica. These concentrations are an important factor in determining water quality. However, the particle-specific interactions controlling metals are poorly understood. Linkages between silica and phosphorus removal and regeneration are controversial.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 16

ASSEL, R.A.

Michigan - NOAA/GLERL, Ann Arbor

## GREAT LAKES NEARSHORE ICE FORECASTS

Starting date: 1986

Completion date: 1987

Project no: Task 8.19

Sponsor: NOAA

AREA: Escanaba Harbor; Lake Michigan; Duluth Harbor; Lake Superior; Saginaw Bay; Lake Huron; Anchor Bay; Lake St. Clair

### KEYWORDS:

physical, ice, model, ice growth, temperature, ice breakup, ice formation

### DESCRIPTION:

#### Objectives:

- (1) Develop ice formation, growth, and breakup forecasts for selected bay and harbor sites on the Great Lakes. This will be done using ice formation forecast based on Bilello's (1964) method, ice growth forecast based on Stefan solution to ice growth equation, and ice breakup forecast based on correlation of observed breakup dates with associated ice and air temperatures.
- (2) Develop computer algorithms to access GLERL's nearshore ice forecasting techniques in operational mode.



# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 17

ASSEL, R.A.; QUINN, F.H.  
Michigan - NOAA/GLERL, Ann Arbor

## PRELIMINARY ANALYSIS OF IMPACT OF CLIMATIC CHANGE ON GREAT LAKES ICE CYCLES

Starting date: 1987  
Completion date: Continuing  
Project no: Task 8.21  
Sponsor: NOAA

AREA: Great Lakes; Lake Erie; Lake Superior

### KEYWORDS:

physical, climate, meteorology, temperature, ice,  
carbon dioxide, model, winter

### DESCRIPTION:

Under the current climatic regime, ice cover begins to form in bays and harbors of the Great Lakes in December. Ice forms on the deeper bays and perimeter of the Great Lakes in January and in the mid-lake areas in February. Seasonal maximum ice extent usually occurs the last half of February. Our first efforts to assess the impact of a climatic change on Great Lakes' ice cover were directed toward modeling the effects of increased average winter air temperature on regional maximum ice cover. Simulations over a base period of 1900-1980 indicate regional maximum ice cover ranged from 92% for the four coldest winters to 16% for the four warmest winters. Simulated average maximum ice extent for the current climatic regime (1951-1980) is 58%. Under a 2 x CO<sub>2</sub> warming (4-5 degree C temperature increase) simulated seasonal maximum ice extent ranges from 0% to 9%. Work is now underway to assess the impact of climatic change on the entire Great Lakes' ice cycle. Bilello coefficients are being developed for simulating surface water temperature decline during the fall and early winter cooling period. Freezing degree-days and thawing degree-days are being correlated with ice cover extent to develop empirical models to simulate ice extent during ice growth and ice decay periods of Lake Erie and Lake Superior ice cycles.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 18

AUER, M.

Michigan - Michigan Technological University, Houghton  
Civil Engineering Dept.

DISSOLVED OXYGEN DYNAMICS IN GREEN BAY: AN ECOSYSTEM APPROACH

Starting date: 1981

Completion date: 1984

Project no:

Sponsor: U.S. EPA - Washington, D.C.

AREA: Lake Michigan; Green Bay

KEYWORDS:

chemistry, dissolved oxygen, sediments, circulation,  
water quality

DESCRIPTION:



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 19

AUER, M.

Michigan - Michigan Technological University, Houghton  
Civil Engineering Dept.

TRIBUTARY LOADINGS TO GREEN BAY: A MASS BALANCE APPROACH

Starting date: 1982

Completion date: 1984

Project no:

Sponsor: U.S. EPA - Duluth

AREA: Green Bay; Fox River; Lake Michigan; tributaries

KEYWORDS:

nutrients, chemistry, phosphorus, sediments, tributaries,  
loading, discharge, water quality, inorganics

DESCRIPTION:

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 20

BANASZAK, K.J.; SHEDLOCK, R.J.; WATSON, L.R.  
Indiana - U.S. Geological Survey, Indianapolis

PRELIMINARY ANALYSIS OF GROUNDWATER SYSTEM IN THE  
DRAINAGE BASIN OF THE GRAND CALUMET RIVER/INDIANA  
HARBOR CANAL, NORTHWEST INDIANA

Starting date: 6/1985  
Completion date: 9/1986  
Project no: IN 85-102  
Sponsor: U.S. EPA

AREA: Indiana; Grand Calumet River; Indiana Harbor Canal; Lake  
Michigan

KEYWORDS:

geology, groundwater, hydrology, river, pollution,  
sediments, aquifer, model, water quality, flow,  
contaminants, sediment cores, tributaries

DESCRIPTION:

Problem:

Whether the quality of the Grand Calumet River/Indiana Harbor Canal and Lake Michigan has been or could be locally or extensively altered by inflows of contaminated groundwater. The design of a sampling scheme to determine the quality of ground water and the eventual movement of contaminants requires a preliminary analysis of the flow system because it is transient.

Objective:

To achieve a preliminary understanding of the functioning of the hydrogeologic system. This understanding will allow decisions to be reached as to how to study this system effectively.

Approach:

- (1) Collect all existing data.
- (2) Vibracore sediments to gain an appreciation of subtle lithologic changes in the aquifer.
- (3) Place six transects of shallow, recording groundwater wells and of stage recorders.
- (4) Do preliminary groundwater flow modeling.

Results:

Eight vibracores and twelve wells were placed in 1985. Additionally, permission was received from owners of nine other wells to use them in the network. A set of black and white airphotos of the study area at one inch to 1000 ft. has been obtained. After finishing preliminary modeling to quantitatively understand flow, a full scale study is scheduled to begin in mid-1986. See next project entry for further description of that study.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 21

BANASZAK, K.J.; WATSON, L.R.; FENELON, J.M.  
Indiana - U.S. Geological Survey, Indianapolis

WATER QUALITY OF THE CALUMET AQUIFER IN THE DRAINAGE BASIN  
OF THE GRAND CALUMET RIVER/INDIANA HARBOR CANAL,  
NORTHWEST INDIANA

Starting date: 6/1986  
Completion date: 9/1988  
Project no: IN86-107  
Sponsor: Indiana Dept. of Environmental Management

AREA: Lake Michigan; Grand Calumet River; Indiana Harbor  
Canal; Indiana

KEYWORDS:

water quality, groundwater, aquifer, pollutants,  
hydrology, contaminants, tributaries, river, geology,  
model, flow, transport, toxics

DESCRIPTION:

Problem:

Whether the quality of water in Lake Michigan or the  
Grand Calumet River/Indiana Harbor Canal is or could  
be affected by inflows of groundwater.

Objective:

To characterize groundwater quality in the area and then  
determine the potential for migration of contaminants,  
especially toxics, to the Grand Calumet River/Indiana  
Harbor Canal and Lake Michigan.

Approach:

Collect new information on the quality of groundwater  
in the area, construct a flow model for the area, and  
construct flow nets on which water quality characteristics  
have been superposed in order to estimate the potential  
for advective transport.

Results:

Thirty stainless steel 316 wells have been set. An  
areal model of groundwater flow is under construction.  
Preliminary chemical analyses have been done.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 22

BAUMANN, P.C.; SCHMITT, C.J.; FABACHER, D.L.  
Missouri - U.S. Fish and Wildlife Service, Columbia  
Columbia National Fisheries Research Laboratory;  
Ohio - U.S. Fish and Wildlife Service, Columbus

## GREAT LAKES: FISH AND WILDLIFE CONTAMINANTS

Starting date: 2/1984  
Completion date: 9/1987  
Project no: Project 889  
Sponsor: U.S. Fish and Wildlife Service

AREA: tributaries; harbors; Milwaukee Harbor; Lake Michigan;  
Green Bay; Great Lakes

## KEYWORDS:

water quality, tributaries, chemistry, DDT, PCBs, dioxins, toxaphene, chlordane, dibenzofurans, organics, sediments, organochlorine pesticides, fish, biology, physiology, carcinogens, tumors, transport, contaminants, monitoring, brown bullhead, walleye, harbors, toxics, bioassay

## DESCRIPTION:

### Problem:

Fish populations with elevated frequencies of liver cancer have been documented in a number of streams tributary to the Great Lakes. All of these locations were found to contain known carcinogenic contaminants that are by-products of industrial processes or coking operations.

### Objectives:

- (1) To determine the extent of contamination of fish and sediments in Great Lakes tributary streams.
- (2) To evaluate relationships of physiological and morphological aberrations in fish inhabiting Great Lakes' tributaries to toxic and carcinogenic contaminants.
- (3) To identify sources of input and investigate contaminant transport in Great Lakes' fishes.
- (4) To evaluate the significance of tumor to fish and affected populations.

### Results:

Five tributaries were selected for study in FY84 based on identified carcinogen sources; additional locations were studied in FY85 and FY86. Sediments and fish were analyzed for carcinogens. Correlations between the presence of specific carcinogens and tumor frequency were made. In vitro tests on sediment extracts were performed to determine if contaminants

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

in extracts were mutagenic. In vivo exposure of medaka with sediment extracts were done to determine if the contaminants induce tumors in fish.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 23

BELL, G.L.; EADIE, B.J.; ROBBINS, J.A.  
Michigan - NOAA/GLERL, Ann Arbor

FLUX MEASUREMENTS IN LAKES MICHIGAN, HURON, AND SUPERIOR

Starting date: 4/1982  
Completion date: 12/1987  
Project no: Task 3.10  
Sponsor: NOAA

AREA: Lake Michigan; Lake Huron; Lake Superior

KEYWORDS:

physical, flux, resuspension, stratification, chemistry, tracer, settling, transport, particulates, water quality, nepheloid layer, sedimentation, sediment traps, radionuclides, model, PAHs, PCBs, silica, phosphorus, organic carbon, organics, toxics, nutrients, inorganics

DESCRIPTION:

Objectives:

To (1) measure the primary and resuspension mass fluxes in Lakes Michigan, Huron, and Superior during thermally stratified and unstratified periods, (2) quantify the chemical fluxes for selected tracers in these lakes, and (3) develop a model to simulate the process of settling and resuspension of particulates.

Approach:

Sediment trap data collected monthly during 1982 at station 7 (alternately numbered 17) west of Grand Haven in Lake Michigan, and data from 11 stations distributed from the southern to the northern basin will be used to calculate the mass flux during thermally stratified and unstratified periods. The 11 stations were established by attaching one to four sediment traps to current meter moorings. To provide information on primary and resuspension fluxes in Lakes Superior and Huron, 4 trap moorings were deployed in each lake in July 1984, retrieved and redeployed in September 1984, and retrieved finally in July 1985. During the same periods, deployments made at three or four stations in Lake Michigan for which we now have several years data will estimation of the temporal representativeness of the upper lake calculations. Flux values measured for summer 1985 were similar to the earlier collections, indicating that sampling was done during a "representative" year. A significant increase in mass influx during the unstratified period was observed in all three lakes.

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

A trap intercomparison study was initiated at the 100-m station in June 1985. GLERL traps are being deployed along with smaller diameter, higher aspect ratio traps used in Lakes Ontario and Erie by the CCIW. This study will continue through 1986. The data will allow two large data sets to be used without bias.

Measurements of Cs-137 and Be-7 will be made on the trap samples to determine the amount of materials being resuspended and those undergoing primary sedimentation. Other chemical analyses will include selected synthetic organics and nutrients for mass balance calculations.

### Accomplishments:

Results to date have been presented at various conferences and three papers have been published which detail the results.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 24

BENNETT, J.R.; CLITES, A.H.  
Michigan - NOAA/GLERL, Ann Arbor

MODELING TRANSPORT OF TOXIC SUBSTANCES

Starting date:  
Completion date: 1985  
Project no: Task 1.9  
Sponsor: NOAA

AREA: Great Lakes; Lake Michigan

KEYWORDS:  
model, temperature, physical, currents, advection,  
circulation, water quality, particulates, chemistry,  
decay, sedimentation, diffusion, toxics,  
resuspension, organics, stratification

DESCRIPTION:

Objective:

The objective of this task is to predict the temporal and spatial movement of toxics in the Great Lakes. A two-dimensional vertically integrated model and a three-dimensional, thermally stratified numerical model will be used to calculate currents in Lake Michigan. These currents will then drive a water quality model that will advect, diffuse, decay, settle, and resuspend particles and dissolved chemicals.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 25

BENNETT, J.R.; MILLER, G.S.; SAYLOR, J.H.  
Michigan - NOAA/GLERL, Ann Arbor

ANALYSIS OF LAKES ERIE AND MICHIGAN DATA

Starting date:  
Completion date: 1985  
Project no: Task 1.2  
Sponsor: NOAA

AREA: Lake Erie; Lake Michigan

KEYWORDS:

model, circulation, interbasin exchange,  
physical, water budget

DESCRIPTION:

Objectives:

- (1) To describe and understand the circulation of Lake Erie, including the distributions and volumes of interbasin exchange processes.
- (2) To study dynamical processes observed in Lake Michigan.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 26

BENNWITZ, T.

Wisconsin - Wisconsin Dept. of Natural Resources, Madison

MILWAUKEE HARBOR ESTAURY COMPREHENSIVE PLANNING  
PROGRAM

Starting date: 5/1981

Completion date: 6/1985

Project no: WI-104

Sponsor: Wisconsin Dept. of Natural Resources; U.S.  
Geological Survey; Southeastern Wisconsin Regional  
Planning Commission

AREA: Milwaukee River; Southern Lake Michigan

KEYWORDS:

chemistry, pollution, wetlands, abatement, management,  
water quality, inorganics, nutrients, phosphorus,  
organics, toxics, contaminants, model, eutrophication,  
tributaries, nonpoint source, point source, loading

DESCRIPTION:

The primary purpose of this study is to determine the nature of the pollution problems in the Milwaukee estuary including sources, effects, and potential abatement strategies. This project includes the collection of water quality data, modeling studies, and an evaluation of abatement alternatives as cost-effective options.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 27

BIERMAN, V.J., JR.

Indiana - University of Notre Dame, Notre Dame  
Dept. of Civil Engineering

A MODELLING PERSPECTIVE ON SOURCES OF TOXICS  
IN THE GREAT LAKES

Starting date:

Completion date: Continuing

Project no:

Sponsor: Sponsor Not Known

AREA: Great Lakes

KEYWORDS:

chemistry, model, mass balance, toxics, PCBs,  
DDT, organics, resuspension, sediments, food chain,  
point source, flux, volatilization, organochlorine  
pesticides

DESCRIPTION:

The objective of mass balance modeling for toxics is to develop quantitative relationships between sources and concentration distributions in the water column, sediments, and biota. This requires data for sources and distribution that are sufficient to balance mass to within an acceptable level of uncertainty. Contemporary data bases for toxics in the Great lakes are not sufficient for credible modeling analyses of fate and responses. An additional complication is that in-place toxics constitute potential sources for most of the Areas of Concern. In-place toxics are not amenable to direct measurement over space and time scales of interest. Despite these obstacles mass balance models can be used to estimate bounds on source inputs, and they provide the only practical way to estimate relative contributions from in-place toxics. Results from selected case studies of PCBs and DDT indicate that:

- (1) Sediment resuspension can be a net source of toxics to the water column.
- (2) Uncertainty in the significance of volatilization is an important factor confounding the estimate of total source inputs.
- (3) Tissue residues of PCBs in top predator species are ultimately controlled by dissolved phase concentrations in the water column.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 28

BINKOWSKI, F.P.

Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies

EN MASSE PRODUCTION OF METHYL-TESTOSTERONE STERILIZED  
CHINOOK SALMON TO ENHANCE THE TROPHY FISHING  
OPPORTUNITIES ON LAKE MICHIGAN

Starting date: 9/01/1985

Completion date: 6/30/1986

Project no:

Sponsor: Wisconsin Dept. of Natural Resources

AREA: Lake Michigan

KEYWORDS:

biology, fish, chinook salmon, hormones, physiology,  
reproduction, sterilization, salmonid

DESCRIPTION:

Methods of sterilization of chinook salmon are being investigated because sterile salmon would hopefully grow larger than reproducing salmon, and result in larger trophy fish if stocked in Lake Michigan.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 29

BINKOWSKI, F.P.

Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies

THE BIOENERGETICS OF THE GREAT LAKES BLOATER (CHUB)

Starting date: 9/01/1980

Completion date: 8/31/1984

Project no: R/LR-18

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Laboratory

KEYWORDS:

fish, growth, metabolism, bioenergetics, biology, diet,  
physiology, respiration, food consumption, bloater, chub,  
larval fish, forage fish

DESCRIPTION:

Objectives:

To conduct physiological experiments related to respiration and food consumption of the Great Lakes bloater or chub (*Coregonus hoyi*) as functions of temperature and body size (wet weight).

Specifically: (1) to determine the routine metabolism of young-of-the-year, yearling and adult chub by measuring their oxygen consumption; (2) to measure the maximum daily ration of young-of-the-year, yearling and adult chubs.

Rationale:

Bioenergetics information on the bloater is needed for computer models of fish growth and of the bioaccumulation of toxic substances. Chub bioenergetics data is being solicited by state and federal agencies responsible for managing both the commercial chub fishery (valued at more than \$1 million in Wisconsin) and the salmonids that prey on chubs.

Accomplishments:

Field collected 200,000 fertilized chub eggs. Larval fish, hatched in laboratory, later used to study chub respiration and food consumption. Chub data used to develop comparative bioenergetics picture of major Lake Michigan forage fishes, including a study of food consumption by bloaters weighing from one to over 200 gms. at four temperatures and a representative data set from oxygen consumption experiments. Lake Michigan chubs appear to be a more efficient converter of invertebrate food resources.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 30

BINKOWSKI, F.P.

Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies

SPAWNING INDUCTION OF LAKE TROUT AND ANALYSIS OF  
REPRODUCTION HORMONE LEVELS IN LAKE TROUT BLOOD

Starting date: 10/01/1985

Completion date: 8/31/1986

Project no:

Sponsor: Wisconsin Dept. of Natural Resources

AREA: Laboratory

KEYWORDS:

biology, fish, lake trout, reproduction, spawning,  
hormones, physiology

DESCRIPTION:

The primary objective was to develop induced spawning procedures by testing several exogenous hormonal substances (hypothalamic and pituitary) on lake trout. A second objective was to examine the reproductive traits and physiological condition of spawning fish and compare these reproductive characteristics between native and stocked populations. Fish administered hormones (LHRHa and combination SG-G100 and LHRHa) exhibited 100% ovulatory response by the end of the study. The control group (saline injected) had a 73% ovulatory response. Hormonally induced spawning of lake trout is feasible and LHRHa produced the best response at a dose of 0.1 mg/Kg of body weight. No significant difference was observed in the reproductive traits and physiological condition between native and stocked lake trout.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 31

BINKOWSKI, F.P.

Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies

AN INVESTIGATION OF THE CULTURE TECHNIQUES AND  
EARLY LIFE HISTORY OF THE LAKE STURGEON

Starting date:

Completion date: 1984

Project no: R/LR-26

Sponsor: University of Wisconsin Sea Grant Institute; Sea  
Farms Company of Norway; Wisconsin Electric Power  
Co.

AREA: Laboratory

KEYWORDS:

biology, fish, aquaculture, production, sturgeon,  
growth, survival, diet, temperature, life history

DESCRIPTION:

Objectives:

To (1) conduct feeding trials in the laboratory;  
(2) detail the feeding behavior; (3) compare the growth  
and survival of lake sturgeon relative to different  
prepared diets and temperatures; (4) investigate the  
feasibility of raising lake sturgeon in net cages using  
power plant warm water discharge ponds.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 32

BINKOWSKI, F.P.; CROWDER, L.

Wisconsin - University of Wisconsin - Milwaukee  
Center for Great Lakes Studies;

North Carolina - North Carolina State University, Raleigh  
Zoology Dept.

ZOOPLANKTON SIZE AND RECRUITMENT SUCCESS OF BLOATER  
(COREGONUS HOYI).

Starting date: 9/01/1986

Completion date: 8/31/1988

Project no: R/LR-33

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Lake Michigan; Laboratory

KEYWORDS:

biology, fish, bloater, chub, Coregonus, feeding, diet,  
behavior, zooplankton, larval fish, predation, prey,  
recruitment, growth, size

DESCRIPTION:

Objectives:

To (1) provide a laboratory test of the hypothesis that growth rates of post-larval bloaters are dependent on zooplankton size; (2) examine the ontogeny of feeding behaviors of post-larval bloaters; and (3) determine the ontogeny of size selectivity in bloaters. These specific objectives relate to critical juvenile fish-zooplankton interactions in the Great Lakes.

Methodology:

Perform a series of laboratory experiments to test the feeding and growth responses of bloaters to zooplankton size availability. These experiments will use live Lake Michigan zooplankton and hand-reared bloater juveniles.

Rationale:

Our recent work on recruitment mechanisms of bloaters suggests they are highly resistant to starvation but that predation on larvae may be size- or growth rate-dependent. Foraging theory suggests poor growth may be associated with small zooplankton size, which may prolong bloater larvae vulnerability to predators and cause poor recruitment like that which occurred in the 1960s.

Accomplishments:

Recent publications directly related to our last four years of research on recruitment mechanisms of larval bloater include one paper out, two in press, and three submitted.



## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

### Benefits:

Bloaters are now the most abundant fish in the offshore zone of Lake Michigan and have produced poor year classes when the adults were abundant (1960s) and strong year classes when the adults were rare (1980s). This study will help clarify the mechanism underlying this recruitment variation. Previous work has shown that predation is more likely than feeding to influence success in the larval stage. This work will be useful to state and federal fisheries managers and researchers on the Great Lakes as well as fisheries and aquatic ecologists nationwide.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 33

BINKOWSKI, F.P.; GETZ, R.

Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies;

Indiana - University of Notre Dame, Notre Dame  
Biology Dept.

CHINOOK SALMON STERILIZATION

Starting date: 1983

Completion date: 1984

Project no:

Sponsor: Wisconsin Dept. of Natural Resources

AREA: Laboratory

KEYWORDS:

biology, fish, chinook salmon, growth, sterilization,  
physiology, weight gain, salmonid

DESCRIPTION:

The primary objective of this study was to treat chinook salmon during the sac-fry stage and at the onset of first feeding through the 12-week fingerling stage with a steroid substance to promote sterilization. Sterile salmon would hopefully grow larger than reproducing salmon and result in larger trophy fish if stocked in Lake Michigan.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 34

BINKOWSKI, F.P.; KITCHELL, J.F.; CROWDER, L.  
Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies;  
Wisconsin - University of Wisconsin-Madison  
Zoology/Center for Limnology;  
North Carolina - North Carolina State University-Raleigh  
Zoology Dept.

DAILY GROWTH RATES AND VARIABLE RECRUITMENT OF  
LARVAL FISHES IN LAKE MICHIGAN

Starting date: 4/01/1982  
Completion date: 8/31/1986  
Project no: R/LR-22  
Sponsor: University of Wisconsin Sea Grant Institute

AREA: Lake Michigan; Laboratory

KEYWORDS:

biology, otoliths, neuston, predation, chub, forage fish,  
bloater, alewife, fish, growth, larval fish, recruitment,  
diet, survival, year-class strength, age, mortality, sculpin

DESCRIPTION:

Objectives:

To investigate the growth, feeding and survival of  
fish larvae and the mechanisms underlying year-class  
strength of fishes, focusing on bloater chub and alewife,  
by determining the type and reliability of information  
stored in the otolith growth increments in these fishes;  
by using this information to interpret the age and growth  
history of field-caught larvae to elucidate patterns and  
causes of mortality; and by evaluating neuston sampling  
of larvae as a means of year-class assessment.

Methodology:

Analysis of daily growth increments in otoliths of larval  
fish to determine age and growth rates, and to identify  
periods of stress due to starvation on low ration during  
the growth history of individual fish.

Rationale:

Effective fisheries management requires accurate forecasts  
of recruitment. Understanding the mechanisms governing  
recruitment success is a central problem in fisheries  
research. These issues need to be addressed for Lake Michigan  
fish populations which are important both commercially  
(bloater) and as forage for the salmonid sport fishery  
(alewife).

Accomplishments:

Laboratory studies determining the type and reliability of

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

information that can be derived from otoliths of larval bloaters have been completed, along with experiments documenting the effects of starvation and delaying first feeding on the growth, mortality and swimming ability of larval bloaters. Two years of data on seasonal and spatial distribution and relative abundance of larval bloaters have been collected. Laboratory experiments based on prey density and substrate type proved that sculpin prey on chubs in all early life stages; cannibalization by adult and sub-adult chubs is far less. For alewife larvae research, collected gametes from spawning alewives, eventually producing sac fry, which refused feed and died. In 1986, tested new experimental diet on sac fry.

### Benefits:

Field data are being communicated to the Wisconsin DNR. The data should determine the feasibility of a larval assessment to determine year-class strength of bloaters. If successful, this method would provide two more years of management lead time than the current 2+ assessment. Insights into causes of recruitment variability will be of specific value to Lake Michigan fish managers and of general interest to fisheries research.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 35

BISHOP, R.

Wisconsin - University of Wisconsin-Madison  
Agricultural Economics

ECONOMIC ANALYSIS FOR MANAGEMENT OF THE GREEN BAY  
FISHERIES AND OTHER GREAT LAKE FISHERIES OF  
WISCONSIN

Starting date: 9/01/1983

Completion date: 8/31/1986

Project no: R/PS-32

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Green Bay; Lake Michigan

KEYWORDS:

model, biology, allocation, management, economics, fish,  
yellow perch, walleye, commercial fishing,  
sport fishing, value, lake trout, rehabilitation

DESCRIPTION:

Objectives:

To: (1) complete an economic analysis of alternative management policies for Green Bay yellow perch in an investment framework; (2) apply the same type of analysis developed under objective 1 to Green Bay walleye management; (3) analyze data on Great Lakes commercial and recreational fishing in order to provide relevant information to public agencies and interest groups with particular emphasis on lake trout policies.

Methodology:

A conceptual framework drawn from investment theory as applied to fisheries. Development of recreational fishing values using contingent valuation and travel cost models and of commercial fishing analyses using standard cost and return techniques.

Rationale:

To provide economic analyses of policy alternatives affecting productivity of Green Bay perch and walleye stock, allocation of harvest between sport and commercial fishing, allocation of walleye hatchery capacity between Green Bay and inland waters, and lake trout rehabilitation efforts so that both economic and biological effects can be considered in making public decisions.

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

### Accomplishments:

Determined benefits and costs to commercial fishermen that would result from varying degrees of success in the Wisconsin Dept. of Natural Resources perch restoration plan. Principal finding: With full success, fishermen break even over a 10-yr period (compared to no DNR plan), and they come out slightly ahead over a 15-yr period. Sport fishers benefit most under the DNR plan, successful or not.

### Benefits:

PI was appointed to the ad hoc task force on Great Lakes fisheries, which was assigned responsibility for considering alternative ways of financing state fisheries management programs. Data from Sea Grant research was used to provide general information and to develop a computer model used to consider the state revenues and other economic implications of alternative commercial fishing fees; the computer model was used to design the fee structure recommended by the task force.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 36

BISHOP, R.

Wisconsin - University of Wisconsin-Madison  
Agricultural Economics

## ECONOMIC ANALYSIS OF LAKE TROUT MANAGEMENT

Starting date: 9/01/1986

Completion date: 8/31/1988

Project no: R/PS-33

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Lake Michigan

### KEYWORDS:

economics, fish, lake trout, management, value, salmonid,  
sport fishing, commercial fishing, rehabilitation

### DESCRIPTION:

#### Objectives:

To (1) estimate the economic gains and losses from several possible lake trout management strategies; (2) assess the impact of enforcement costs and illegal activity on the workability of these strategies; (3) further develop the theory of existence values and the methodology for estimating the existence values associated with reestablishing self-sustaining lake trout stocks.

#### Methodology:

Analysis via an investment framework developed by the P.I.; management strategies developed in consultation with biologists, agency personnel and user groups; data to evaluate scenarios gathered from surveys of user groups and government sources.

#### Rationale:

Extensive efforts to reestablish self-sustaining lake trout populations in Lake Michigan have failed. Major decisions are in offing regarding continuation of this effort, as costs may be large both in terms of out-of-pocket expenditures and restrictions on sport and commercial fishing. An economic evaluation of alternatives will facilitate the decision process.

#### Accomplishments:

With Sea Grant support, the P.I. and his students have developed an economic framework (the investment strategy mentioned above) for applying cost-benefit concepts to fisheries management decisions. This framework is currently being applied to Wisconsin's Green Bay yellow perch fishery.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 37

BISHOP, R.

Wisconsin - Heberlein Baumgartner Research Services  
4513 Vernon Boulevard, Madison, WI 53705

A STUDY OF THE ECONOMIC VALUE OF ILLINOIS BEACH  
STATE PARK NATURE PRESERVE

Starting date: 10/1984

Completion date: 11/1985

Project no:

Sponsor: Illinois Dept. of Conservation

AREA: Illinois Beach State Park; Southern Lake Michigan

KEYWORDS:

economics, value, tourism, recreation

DESCRIPTION:

Objectives:

1. Define the specific economic values applicable to valuation of the Illinois Beach Nature Preserve based upon a review of current resource economics literature.
2. Determine the appropriate aggregate economic value of the Illinois Beach Nature Preserve by determining both users' and non-users' willingness-to-pay to protect and maintain the Preserve.
3. Determine the applicability of the Illinois Beach Nature Preserve economic valuation methodology and/or results to other sites in Illinois.
4. Determine if reasonable estimates of the economic value of the Illinois Beach Nature Preserve or similar sites can be made without use of survey research.

Publications:

"The Economic Value of Illinois Beach State Nature Preserve," Final Report to the Illinois Dept. of Conservation, December 1985.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 38

BLACK, J.

New York - Roswell Memorial Institute, Buffalo

FISH TUMOR GUIDE

Starting date: 10/1984

Completion date: 9/1986

Project no: EPA04-0265

Sponsor: U.S. Environmental Protection Agency

AREA: Lake Michigan; Lake Erie; Lake Huron; Lake Superior;  
Lake Ontario

KEYWORDS:

biology, fish, lake trout, physiology, pathology

DESCRIPTION:

The purpose of this project is to develop a guide for identifying various tumors found in Great Lakes fish. This guide should be published by the Great Lakes Fishery Commission in summer 1987.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 39

BOLSENGA, S.J.

Michigan - NOAA/GLERL, Ann Arbor

SURVEY OF GREAT LAKES ICE RESEARCH

Starting date: 1986

Completion date: Continuing

Project no: Task 8.17

Sponsor: NOAA

AREA: Lake Michigan; Lake Superior; Lake Huron; Lake Erie;  
Lake Ontario

KEYWORDS:

physical, ice, winter, temperature

DESCRIPTION:

Objective:

To compile a summary of scientific studies on the physics and chemistry of Great Lakes ice.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 40

BOLSENGA, S.J.; FAHNENSTIEL, G.L.; QUIGLEY, M.A.;  
VANDERPLOEG, H.A.

Michigan - NOAA/GLERL, Ann Arbor

UNDER-ICE ECOLOGY--PILOT PROGRAM

Starting date: 1986

Completion date: 1986

Project no: Task 8.15

Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

biology, botany, phytoplankton, zooplankton, benthic,  
invertebrates, populations, ice, physical, temperature,  
winter

DESCRIPTION:

Objective:

To obtain a better understanding of phytoplankton,  
zooplankton, and benthic macroinvertebrate population  
dynamics under winter conditions.

This project is continuing as Task 6.49 entitled  
"Winter Ecology" under direction of H.A. Vanderploeg.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 41

BOLSENGA, S.J.; HERDENDORF, C.E.

Michigan - NOAA/GLERL, Ann Arbor;

Ohio - Ohio State University, Columbus

DEFINITION OF SPECTRAL TRANSMITTANCE THROUGH ICE AND  
SNOW IN THE 300-1100NM RANGE

Starting date: 1987

Completion date: Continuing

Project no: Task 8.22

Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

physical, ice, snow, winter, remote sensing, irradiance

DESCRIPTION:

GLERL is currently involved in a joint program with Ohio State University to obtain through ice spectral transmittances and to correlate that information with data gathered on the state of the biota under the ice.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 42

BORAAS, M.E.; NEALSON, K.; REMSEN, C.C.;  
SEALE, D.B.

Wisconsin - University of Wisconsin-Milwaukee  
Dept. of Biological Sciences and Center for  
Great Lakes Studies

PHAGOTROPHIC FLAGELLATES IN LAKE MICHIGAN

Starting date:  
Completion date: 1986  
Project no:  
Sponsor: Sponsor Not Known

AREA: Lake Michigan

KEYWORDS:

biology, microbiology, flagellates, zooplankton,  
zooplankton grazing, invertebrates, abundance

DESCRIPTION:

Flagellates from Lake Michigan were counted using epifluorescence microscopy for one year. Additionally, colorless flagellates were sized with image analysis and scored for the presence and type of apparent food vacuoles. Numbers ranged from 3000-5000/ml in the spring to 1000/ml during stratification with a low of 200-300/ml in the winter. The mean size was usually < 4 microm. after fixation. Laboratory studies using plastic beads and live food cells on isolated flagellate species demonstrated size-selective feeding by a large (> 10 microm.) Ochromonas, which fed only on particles about one half to roughly equal its own length. A smaller species readily ingested Xenorhabdas, a freshwater bioluminescent bacterium, comparable in size to many cyanobacteria, at a rate sufficient to clear the water column on a daily basis.

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LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 43

BOWERS, J.

Michigan - University of Michigan, Ann Arbor  
Great Lakes Research Division

IMPROVED POPULATION ESTIMATES OF MYSIS RELICTA IN  
LAKE MICHIGAN

Starting date: 1985  
Completion date: 1987  
Project no:  
Sponsor: National Science Foundation

AREA: Lake Michigan

KEYWORDS:

biology, Cladocera, zooplankton, populations,  
Mysis, vertical migration, invertebrates, prey,  
predation

DESCRIPTION:

Volumetric population estimates of mysid shrimp in Lake Michigan yielded predator-prey ratios not possible with conventional net or sled tows. Vertical migration permits Cladoceran prey to escape mysid predators during the summer months.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 44

BOWERS, J.

Michigan - University of Michigan, Ann Arbor  
Great Lakes Research Division

PHOSPHORUS RELEASE BY ZOOPLANKTON

Starting date: 1982  
Completion date: Continuing  
Project no:  
Sponsor: NOAA/GLERL

AREA: Lake Michigan; Laboratory

KEYWORDS:

biology, zooplankton, nutrients, chemistry, phosphorus,  
regeneration, temperature, Rotifera, diet, Copepoda,  
foraging rates, inorganics, zooplankton grazing

DESCRIPTION:

This study correlated the phosphorus regeneration rates  
of a predatory copepod and two pelagic rotifers to their  
foraging rates and temperature.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 45

BOWLBY, J.R.

Ontario - Ontario Hydro, Toronto

REDETERMINATION OF GLACIO-ISOSTATIC UPLIFT  
AND DIFFERENTIAL TILTING OF THE LAURENTIAN  
GREAT LAKES BASIN

Starting date:

Completion date: Continuing

Project no:

Sponsor: Sponsor Not Known

AREA: Great Lakes Basin

KEYWORDS:

geology, glacial, historical, model

DESCRIPTION:

A new regional model of aggregate uplift has been developed through a cumulative analysis of deformations recorded in adjacent lake basins. For example, the differential uplift of the Lake Ontario outlet sill has formerly been expressed to be about 120 m. When fitted to the regional aggregate model, uplift is determined to be about 175 m at this northeastern outlet. Similar variances in uplift amplitude are determined for the other lake basins. Analysis of lake gauge records indicates that the tilting is continuing, albeit at reduced rates.

Horizontal crustal stress trajectories are inferred from this analysis of post-glacial deformation. This pattern exhibits correlations with measured rock stress orientations, observed structures and earthquake focal solutions derived from the area in and around the basin.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 46

BOYER, L.F.; SHEN, E.F.

Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies;  
Texas - ARCO, Dallas

A SEDIMENT-PROFILE CAMERA STUDY OF MILWAUKEE  
HARBOR, WISCONSIN

Starting date: 6/1984

Completion date: 6/1985

Project no:

Sponsor: University of Wisconsin-Milwaukee Graduate School  
Research

AREA: Milwaukee Harbor; Lake Michigan

KEYWORDS:

geology, sediments, photography, sediment-water interface,  
sediment cores, biology, oligochaetes, oxygen, mapping,  
redox, invertebrates, benthic

DESCRIPTION:

Objective:

77 sediment-profile photographs were taken at 28 stations in Milwaukee Harbor, WI, in order to remotely map the sedimentary characteristics and the benthonic community of the harbor, and to compare these results with core sampling. The photographs were examined in detail and analyzed with computer image analysis techniques. Each photo was examined for: (1) depth of camera penetration, (2) sediment surface relief, (3) area of gas voids, (4) area and depth of oxidized sediment, and (5) abundance of oligochaete worm tubes.

Results:

The depth of the Redox Potential Discontinuity (RPD) increased away from the harbor channel and ranged from 0.25 cm to a maximum of 4.97 cm in the southern harbor. Boundary roughness ranged from a maximum of 3.94 cm near the southern breakwall to 0.22 cm in the central harbor. Three other parameters decreased with distance from the harbor channel: (1) areal % of gas voids within the sediment ranged from 13.1% near Jones Island to zero in the extreme northern and southern harbor, (2) depth of camera penetration -- full penetration occurred in the river channel to <5 cm in the northwestern and southwestern harbor, (3) the abundance of worms ranged from >100,000 tubes/squared meter in the central harbor, to <10,000 tubes/squared meter along the edge of the southern harbor.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 330

BRADEN, J.; HERRICKS, E.

Illinois - University of Illinois, Champaign-Urbana  
Dept. of Agricultural Economics;

Illinois - University of Illinois, Champaign-Urbana  
Dept. of Civil Engineering

EFFICIENT PROTECTION OF FISH HABITAT IN GREAT LAKES  
TRIBUTARIES FROM AGRICULTURAL POLLUTANTS

Starting date: 5/01/1987

Completion date: 4/30/1989

Project no: R/F-8

Sponsor: Illinois/Indiana Sea Grant Program

AREA: Lake Michigan; St. Joseph River

KEYWORDS:

model, tributaries, river, runoff, loading, pesticides,  
fish, habitat, salmon, pollutants, organics, economics,  
management, sediments, nonpoint source, toxics

DESCRIPTION:

Objectives:

1. Develop an analytical framework for identifying selected agricultural pollutants in Great Lakes tributaries, and
2. Show how the framework can be used to protect selected migratory sportfishing species in the St. Joseph River Basin in Indiana and Michigan.

Methodology:

Develop and computerize a framework that links economic choices among farming practices to a pollutant delivery model and, ultimately, to an environmental hazard assessment model for migratory fish. The key features of this model will be direct endogenous attention to economics, and the link to aquatic hazards. Illustrated use of this framework in applications to several reaches of the St. Joseph River, based on crops grown, pesticides used, and migratory fish species found in that Basin.

Rationale:

Pollutants from cropland are pervasive in Great Lakes tributaries, and are major impediments to sportfisheries in the region. Lack of capacity to identify open-quotation priority areas for cost-effective reductions in agricultural pollution hazards is a key limitation of current policy and planning efforts. The proposed framework will help fill this void.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 47

BRAZO, D.C.

Indiana - Dept. of Natural Resources, Michigan City  
Division of Fish and Wildlife

STATUS OF LAKE TROUT IN SOUTHERN LAKE MICHIGAN

Starting date: 5/1985

Completion date: 4/1986

Project no:

Sponsor: Indiana Dept. of Natural Resources

AREA: Lake Michigan; Indiana waters

KEYWORDS:

biology, fish, lake trout, rehabilitation, growth,  
sea lamprey, sea lamprey wounding, reefs, management,  
diet, rainbow smelt, alewife, bloater chub, yellow perch

DESCRIPTION:

Objectives:

1. To determine the condition (status) of the lake trout population in Indiana waters of Lake Michigan,
2. To provide the U.S. Fish and Wildlife Service with current information about lake trout rehabilitation and sea lamprey wounding rates on lake trout in southern Lake Michigan,
3. To provide Indiana State Board of Health with lake trout samples for contaminant analysis, and
4. To evaluate the potential of an offshore reef for lake trout stocking.

Results:

Some 572 lake trout were collected in 20 gill net samples in August. Catch per effort ranged from 0 to 72 fish and was highest in 45-60 feet of water. Of these, 473 fish were aged using fin clips and length data. Age V, VI, and VII fish comprised 66.7% of the catch. Growth rates were 0.74 inches larger for all ages of lake trout from VI-X. Sex ratios were 1.2:1 in favor of males but after age VII, sex ratios were nearly equal. Diets of 491 lake trout were examined. Rainbow smelt and alewives were numerically most important with yellow perch and bloaters as secondary components. Lamprey wound rates were low (0.4%) in lake trout from the Indiana waters of Lake Michigan. Suitable substrate and several juvenile and adult lake trout were observed in scuba operations and gill net lifts at an offshore site.

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

### Conclusions:

Lake trout populations in southern Lake Michigan continue to flourish though no native fish (unclipped) were observed. Distribution is highly correlated to water temperature and preferred temperature seemed to be 46.4-50.0 degrees F. Indeed no lake trout were captured in water temperatures greater than 51.8 degrees F. Mortality rates of fish age IV, VII, and VIII appear to be declining, possibly as a result of daily catch limit restrictions. Growth rates also declined in 1985. Male lake trout mature earlier than females and netted males were 80-90% mature at ages IV and V while females showed less than 50% maturity at those ages. The diet of lake trout remains more varied than other salmonids and rainbow smelt are most important especially to smaller lake trout (<23.7 inches). Alewives are more important to larger fish than small fish. Results from sampling on an offshore reef were encouraging and 115,000 fall fingerling lake trout were stocked by the USFWS in November, 1985.

See Brazo, D.C. (ref. no. 48) for description of continuing studies on fisheries in Lake Michigan.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 48

BRAZO, D.C.

Indiana - Dept. of Natural Resources, Michigan City  
Division of Fisheries and Wildlife

LAKE TROUT POPULATIONS ASSESSMENT AND SPAWNING REEF  
EVALUATION

Starting date: 5/1987

Completion date: 4/1988

Project no:

Sponsor: Indiana Dept. of Natural Resources

AREA: Indiana waters of Lake Michigan; Kintzele (Black) Ditch  
west of Michigan City, Indiana

KEYWORDS:

biology, fish, lake trout, management, rehabilitation,  
spawning, reefs, nursery area, sea lamprey

DESCRIPTION:

Objectives:

1. To determine the condition (status) of the lake trout population in Indiana waters of Lake Michigan,
2. To provide the U.S. Fish and Wildlife Service with current information about lake trout rehabilitation and sea lamprey wounding rates on lake trout in southern Lake Michigan, and
3. To collect baseline data on adult and juvenile lake trout at a potential offshore spawning reef and nursery area for lake trout.

Methodology:

Sampling will be conducted along a transect with the base located at Kintzele (Black) Ditch. A minimum of 500 fish will be collected. Data collected from each fish will include length, weight, sex, state of maturity, fin clips, stomach contents, sea lamprey wounding, and contaminant levels. In addition nets will be set to determine the potential of an offshore area as a lake trout spawning reef.



# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 49

BRECK, J.E.

Tennessee - Oak Ridge National Laboratory, Oak Ridge  
Environmental Sciences Division

## MODELS FOR THE BEHAVIOR AND FATE OF LONG-LIVED CONTAMINANTS IN THE UPPER TROPHIC LEVELS OF THE GREAT LAKES

Starting date: 9/15/1982

Completion date: 1985

Project no:

Sponsor: NOAA/GLERL

AREA: Great Lakes

### KEYWORDS:

biology, model, behavior, fate, contaminants, toxics,  
bioenergetics, PCBs, dieldrin, fish, alewife, salmonid,  
growth, bioaccumulation, uptake, food chain, benthic,  
invertebrates, Pontoporeia, Amphipoda, brown trout,  
rainbow trout, chemistry

### DESCRIPTION:

#### Objective:

The purpose of this project is to develop the capability to estimate the concentrations of contaminants, such as PCBs and dieldrin, in Great Lakes fishes, such as the salmonids and their primary forage, the alewife. The strategy is to adapt previously developed bioenergetics models of fish growth to estimate contaminant uptake and elimination and to analyze the adequacy of the resulting bioaccumulation model. Of special interest is the comparison of the relative contributions of direct uptake from water, pelagic food-chain pathways, and benthic food-chain pathways.

#### Results:

The simulated PCB concentrations were within the range of the observed PCB concentrations in Lake Michigan alewives (approximately 1-5 microg/g). The simulations indicate that PCB uptake through the food chain accounts for more than 80% of the total PCBs accumulated by alewives, with the remainder coming directly from the water. More than half of the total PCBs in alewives is estimated to come from the bottom-dwelling invertebrate *Pontoporeia hoyi*.

A growth model was also applied to data from laboratory experiments on rainbow and brown trout. The model's predictions were all within a factor of 4 (most within a factor of 2) of the average measured chemical concentration of the fish. These simulations account for biological,

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

environmental, and contaminant-specific differences between exposures, and so give estimates that are much closer to the measured values than several estimates from a much simpler model based on a fixed ratio to the chemical concentration in water.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 50

BRIGHAM, L.W.

Wisconsin - University of Wisconsin-Green Bay

SEASONAL ICE COVER AND WINTER CONDITION OF  
GREEN BAY, LAKE MICHIGAN

Starting date: 1980

Completion date: 12/1986

Project no:

Sponsor: University of Wisconsin-Green Bay

AREA: Green Bay; Lake Michigan; Fox River

KEYWORDS:

physical, ice, weather, satellite, LANDSAT,  
bathymetry, river, meteorology, hydrology, flow,  
management, model, remote sensing, winter, historical,  
water use

DESCRIPTION:

This project was conducted as part of master's thesis  
by L.W. Brigham at UWGB. Present address now is:

Office of Operation (G-0)

US Coast Guard Headquarters

2100 Second St., S.W.

Washington, D.C. 20593

Objectives:

- (1) To develop Green Bay Ice Atlas; (2) To infer  
physical processes, spatial patterns, ice cover variability;
- (3) To study major factors influencing ice cover; (4) To  
develop ice cover forecasts for mild/severe/normal winters;
- (5) To review winter waterway management strategies.

Results:

Historical ice charts, as well as NOAA and LANDSAT satellite  
imagery, have been used to establish the characteristic ice  
cover on Green Bay, Lake Michigan for 1972-84. Emphasis is  
placed on the December to April seasonal ice cycle and the  
interannual variations observed during the study period.  
Correlations with local freezing degree day totals are made,  
and the variability in the extent and stability of the cover  
documented. A grid model developed from the ice chart data  
base shows the general ice coverage for severe, average and  
mild winters. Several proposed factors appear to be  
significant influences on the cover and its cycle: the winter  
windfield, Fox River inflow, river water input along the  
western intrusions through the northern passages and  
bathymetry. Comparisons of the general features of the cycle  
show a dynamic northern region heavily influenced by water mass  
movement and meteorological conditions. The central Bay cover



## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

is stable and can be the last ice to deteriorate each spring. The ice cover over the shallow waters of the lower Bay is affected primarily by river water influx. This seasonal ice cycle has obvious impacts on the multiple uses of Green Bay during winter. Waterway management considerations and the implications of competing uses of the Bay's ice cover are reviewed.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 51

BROOKE, L.T.; MCCAULEY, D.J.; BALCER, M.D.  
Wisconsin - University of Wisconsin-Superior  
Center for Lake Superior Environmental Studies

ECOLOGICAL ASSESSMENT OF FACTORS AFFECTING WALLEYE  
OVA SURVIVAL IN THE LOWER FOX RIVER

Starting date: 7/01/1984  
Completion date: 6/30/1986  
Project no: CR-811723-02-0  
Sponsor: U.S. EPA - Duluth

AREA: Green Bay; Fox River; Lake Michigan

KEYWORDS:

biology, chemistry, fish, walleye, larval fish,  
survival, mortality, predation, toxics, organics,  
sediment-water interface, water quality, eggs

DESCRIPTION:

Objectives:

(1) To determine a suitable method for  
in situ walleye ova incubation; (2) To determine  
the effect of substrate on ova survival; (3) To  
identify any differences in ova survival due to  
female differences.

Results:

This study was designed to investigate ova mortality  
as a cause of recruitment failure. Described methods  
for in situ ova incubation, ova sampling, microstrata  
water sampling, and chemical analyses were modified to  
delineate mortality caused by reduced water quality,  
growths of fungus, and egg predation. Notable differences  
in survival were evident when five ova incubation methods  
were compared to test their usefulness as walleye ova  
incubators. Water quality at the sediment/water interface  
was also noticeably different from that in the river  
channel water column.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 52

BROOKS, A.

Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies

THE INFLUENCE OF MYDIS RELICTA ON FISH PRODUCTION  
IN LAKE MICHIGAN

Starting date: 9/01/1982

Completion date: 8/31/1984

Project no: R/LR-25

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Laboratory

KEYWORDS:

biology, invertebrates, zooplankton, food chain,  
larval fish, diet, prey, Mysis, competition,  
fish growth, chub

DESCRIPTION:

This study examined the importance of Mysis relicta in the food web in Lake Michigan. It focused on the questions of: (1) How much do Mysis compete with larval fish for food; (2) do Mysis prey on larval fish, and if so, which species; (3) to what extent do Mysis affect the size of food particles available for smaller zooplankton; (4) how big a factor are Mysis in the diet of the fish that prey on it. Such information will increase man's ability to predict fish growth and standing stocks through a better understanding of how the lake's food web works.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 53

BROOKS, A.; EDGINGTON, D.

Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies

ALGAL PRODUCTIVITY MEASUREMENTS AT GREAT LAKES WATER INTAKES

Starting date: 9/1985

Completion date: 12/1987

Project no: R005880-01

Sponsor: U.S. EPA - Great Lakes National Program Office

AREA: Lake Michigan

KEYWORDS:

chemistry, biology, water quality, phytoplankton,  
botany, primary production, monitoring, nutrients,  
inorganics, phosphorus

DESCRIPTION:

Research to determine if municipal and industrial water intakes can be used to monitor the structure and function of primary producers in the Great Lakes, and if parameters derived from measurements of primary production are appropriate measures of long-term monitoring of ecosystem function. The study compares data from shore-side intake water with lake-side intake water and with open Lake Michigan water.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 54

BROWN, E.; HATCH, R.W.

Michigan - National Fisheries Center - Great Lakes, Ann Arbor

## DEVELOPMENT AND EVALUATION OF MANAGEMENT STRATEGIES FOR GREAT LAKES FISHERY RESOURCES

Starting date: 1980

Completion date: Continuing

Project no:

Sponsor: U.S. Fish and Wildlife Service

AREA: Lake Michigan; Lake Erie; Lake Huron

### KEYWORDS:

management, biology, fish, yellow perch, historical,  
stocking, walleye, whitefish, chub, populations,  
commercial fishing

### DESCRIPTION:

Certain fishery resources in the Great Lakes are presently greatly depressed (e.g., yellow perch in Lakes Erie and Ontario; whitefish in Lake Ontario), in the process of recovery (e.g., chubs in Lakes Michigan and Huron; lake herring in western Lake Superior), or thriving at high levels of productivity (e.g., walleye in western Lake Erie; whitefish in the upper Great Lakes). This work unit provides for participation in coordinated synthesis and analysis of recent/current data and historical records, in order to assist state, tribal, provincial, and international resource agencies in developing and evaluating fishery management strategies, including total allowable catches. Current efforts focus on walleye in Lake Erie, yellow perch in Lakes Michigan and Erie, and chubs and preyfish in Lakes Michigan and Huron.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 55

BURTON, T.

Michigan - Michigan State University, East Lansing  
Dept. of Zoology and Dept. of Fisheries and Wildlife

## NUTRIENT CYCLING AND HYDROLOGIC PROCESSES IN GREAT LAKES COASTAL MARSHES

Starting date: 1980

Completion date: 1985

Project no: R/CW-05

Sponsor: Michigan Sea Grant College Program

AREA: Michigan; Pentwater Marsh; Eastern shore of Lake  
Michigan

### KEYWORDS:

wetlands, biology, chemistry, botany, nutrients,  
hydrology, energy flow, water quality, river, inorganics,  
lake levels, nitrogen, phosphorus, macrophytes, cycling,  
vegetation, aerial photography, water budget

### DESCRIPTION:

Complete water, nitrogen, and phosphorus budgets for the marsh were calculated from input-output data from 1982-85. Vegetation sampling enabled comparison of nutrient uptake and release by various emergent plant communities and assimilation of this into the overall marsh budget. The effects of Lake Michigan lake levels on community structure and nutrient cycling were reconstructed using data on plant communities, nutrient budgets, and changes in plant community structure which occurred as a result of water level changes. The changes in community structure were determined from analysis of aerial photographs. This project led to the Ph.D. dissertation by J.C. Kelley from Michigan State University in 1985.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 56

BUSCH, W.D.N.; SLY, P.G.

New York - U.S. Fish and Wildlife Service, Cortland;  
Ontario - Canadian Centre for Inland Waters, Burlington

## CLASSIFICATION AND INVENTORY OF GREAT LAKES AQUATIC HABITATS

Starting date: 1/1987

Completion date: 2/1988

Project no:

Sponsor: Great Lakes Fishery Commission; International Joint  
Commission; other state, federal, and provincial  
support

AREA: Lake Michigan; Lake Erie; Lake Ontario; Lake Superior;  
Lake Huron

## KEYWORDS:

biology, fish, lake trout, habitat, walleye, model, salmonid

## DESCRIPTION:

### Objectives:

- (1) To identify habitat requirements of biological resources (key species - lake trout, walleye).
- (2) To identify physical, chemical, and biological parameters which can be used as surrogates in identification of habitat types.
- (3) To develop a biologically correct habitat classification system.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 57

CARPENTER, S.

Indiana - University of Notre Dame, Notre Dame  
Biology Dept.

EXAMINATION OF ALGAL PIGMENT DEGRADATION PRODUCTS

Starting date: 1/1/1984

Completion date: 1985

Project no:

Sponsor: National Science Foundation

AREA: Lake Michigan; Benton Harbor; small Michigan lakes

KEYWORDS:

biology, chemistry, paleolimnology, pigments,  
chlorophyll, chromatography, historical, botany,  
sediment cores, phytoplankton

DESCRIPTION:

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 58

CARRICK, H., JR.; LOWE, R.

Ohio - Bowling Green State University, Bowling Green  
Biological Sciences Dept.

## NUTRIENT MANIPULATION OF LAKE MICHIGAN BENTHIC ALGAE

Starting date: 7/15/1984

Completion date: 8/6/1985

Project no:

Sponsor: University of Michigan Biological Station (UMBS);  
Bowling Green State University - Graduate College  
(BGSU)

AREA: Lake Michigan - off east shore of Harbor Pt., Michigan,  
in Little Traverse Bay

### KEYWORDS:

biology, nutrients, benthic algae, sediments, inorganics,  
chlorophyll, phytoplankton, growth, chemistry, botany,  
silica, nitrogen, phosphorus, green algae, diatoms,  
Stigeoclonium, Schizothrix, blue-green algae

### DESCRIPTION:

The response of Lake Michigan benthic algal communities to nutrient enrichment was determined using nutrient-releasing substrates (NRS). Treatments consisted of Si, N+P, Si+N+P, and controls (CONT). NRS were placed in Little Traverse Bay, Lake Michigan at a depth of 10 m and were sampled after 7, 14, and 31 days of exposure. Algal accumulation estimated by chlorophyll-a was greater on NP and SiNP than on CONT and Si on all three sampling dates ( $F=14028$ ,  $P<0.0001$ ). Ratios of particulate silica concentration to chlorophyll-a decreased through time ( $F=83.82$ ,  $P<0.0001$ ) and were greater on CONT and Si relative to NP and SiNP ( $F=9.64$ ,  $P<0.0001$ ). Communities on CONT and Si were composed mainly of diatoms throughout the experiment, whereas communities on NRS enriched with both N and P shifted from a diatom dominated flora to one composed primarily of the green alga *Stigeoclonium tenue* and the blue-green alga *Schizothrix calcicola* after 14 days. A similar shift from a diatom to a green and blue-green dominated community has been observed for upper Great Lakes phytoplankton following NP enrichment. This suggests that both communities may be structured by comparable nutrient processes.

Additional work has shown that nutrient enrichment enhanced the biovolume of a small subset of benthic species. Results from statistical analysis categorize these species into five major groups. These findings suggest that groups of species may have similar nutritional requirements and respond to nutrient perturbations in a similar fashion.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 59

CHEN, K.; DONAHUE, M.

Michigan - University of Michigan, Ann Arbor  
Urban, Technological, and Environmental Planning

INSTITUTIONAL ARRANGEMENTS FOR GREAT LAKES MANAGEMENT:  
PAST PRACTICES AND FUTURE ALTERNATIVES

Starting date: 1/01/1984

Completion date: 1/31/1986

Project no: R/RP-02

Sponsor: Michigan Sea Grant College Program

AREA: Great Lakes

KEYWORDS:

policy, management, economics, review, institutions

DESCRIPTION:

Objectives:

The principal goal of the study is to assist decisionmakers in their ongoing efforts to enhance the efficiency and effectiveness of Great Lakes management. Objectives associated with this goal include: 1) the systematic review of selected regional resource management institutions and institutional arrangements (in the Great Lakes and other regions); 2) the identification of specific institutional characteristics (e.g., membership, geographic jurisdiction, authority) with potential applicability to present and emerging Great Lakes management needs; and 3) based upon this information, the development of alternatives for the revision of existing Great Lakes institutional arrangements and/or the design of new ones.

Methodology:

Examine the underlying theory of regionalism as it applies to resource management; describe the evolution of Great Lakes management efforts, including significant historical actions and events and present institutional arrangements; identify specific institutional characteristics with potential applicability to present and emerging Great Lakes management needs; examine present and emerging Great Lakes management institutions in light of these "desired" characteristics; and use the resultant information to develop alternatives for the

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

revision of existing institutional arrangements and/or the design of new ones.

### Rationale:

The institutional network for Great Lakes management is a highly dynamic one--constantly changing to address new issues and evolving state, federal and international policies. In recent years, the adequacy of existing institutional arrangements in addressing problems has been questioned by many, including Great Lakes Governors (resolution of June 10, 1982). This project is designed to address these concerns by providing an historical perspective on the matter, developing and synthesizing information, and proposing ideas for revising and/or designing alternate institutional arrangements.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 60

CHRISTENSEN, B.; SUTHERLAND, D.

Wisconsin - University of Wisconsin-Madison  
Veterinary Science

FISH PARASITE COMMUNITIES AS INDICATORS OF PREDATOR-  
PREY RELATIONSHIPS IN LAKE MICHIGAN

Starting date: 9/01/1984

Completion date: 8/31/1986

Project no: R/LR-27

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Lake Michigan; Lake Superior

KEYWORDS:

biology, salmonid, lake trout, alewife, smelt, populations,  
predation, diet, parasites, fish, coho salmon, chinook salmon,  
forage fish

DESCRIPTION:

Objectives:

To (1) analyze parasite community structure of Lake Michigan and Lake Superior fish predators (i.e., coho salmon and chinook salmon, lake trout) and their forage fish especially alewife and rainbow smelt, to identify parasites that can serve as biological tags to indicate shifts in salmonid diet; (2) examine recruitment of parasite communities by Lake Michigan's exotic fish species to see if the artificial nature of the system can result in unusual magnification of parasites that might reduce salmonid growth and/or reproduction.

Methodology:

Obtain intestinal tracts, gills, and swimming bladders of salmonids in conjunction with the salmonid diet survey of Kitchell and prey species from DNR Chub Assessment Studies; analyze host-parasite data at UW-Madison computing service facilities.

Rationale:

To provide a variable auxiliary to food stomach analysis for monitoring Lake Michigan salmonid food consumption and increased diversity of diet as seen by Stewart et al.(1981). While stomach analyses indicate prey eaten just prior to fish capture, parasites recruited during ingestion of intermediate hosts remain in intestinal tract for much longer time periods.

Accomplishments:

Necroscopy of more than 1,175 fish representing 28 species from four collecting sites (Racine, Sheboygan, Sturgeon Bay, Bayfield) has resulted in recovery of 46 parasite taxa. Abundance of an Acanthocephalan has been identified as a

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

potential indicator of diet shifts by salmonids. Pathology elicited by parasites inhabiting gulls and eyes of fish is being examined. Parasite data has been shared with USFWS and DNR fishery biologists.



# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 61

CHRISTENSEN, E.

Wisconsin - University of Wisconsin-Milwaukee  
Civil Engineering Dept.

## HISTORICAL RECORDS OF POLLUTANTS IN RECENT AQUATIC SEDIMENTS

Starting date: 9/01/1983  
Completion date: 2/28/1986  
Project no:  
Sponsor: U.S. EPA

AREA: Lake Michigan

### KEYWORDS:

model, water quality, chemistry, geology, sediments,  
sediment cores, pollutants, atmospheric, flux, historical,  
tracer, advection, diffusion, radionuclides, cesium, lead-210,  
lead, zinc, cadmium, dating, organics, PCBs

### DESCRIPTION:

#### Objectives:

- (1) To estimate mixing and compaction parameters of sediments based on the steady-state advection-diffusion equation and steady-state profiles of a radiotracer such as Pb-210.
- (2) To apply the above mixing and compaction parameters in the time-dependent advection-diffusion equation to predict the sediment profile of time-dependent tracers such as Cs-137, Pb, Zn, Cd, and PCBs.
- (3) To investigate the application of the convolution integral to recover the input record of particle-associated substances from the known mixing and compaction parameters of the sediment and a known sedimentary record of the substance considered.

#### Results:

- (1) An efficient scheme for the estimation of mixing and compaction parameters of sediments has been developed. Optimal parameters are determined by minimizing chi-square for calculated and measured Pb-210 activities.
- (2) A comprehensive model for a tracer in sediments has been formulated. The model, which includes mixing and compaction parameters from Pb-210 profiles, has been successfully applied to Cs-137, Pb, Zn, and Cd. The use of Pu-239,240 and Pu-238 as time markers is consistent with the Cs-137 data. PCB levels in sediments of Lake Michigan have declined since 1970 in accordance with U.S. sales records.
- (3) A novel time domain deconvolution method to remove the effects of mixing the sedimentary records of

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

pollutants has been developed. The methods has been tested and successfully applied to Pb, Zn, and Cd in several sediment cores from Lake Michigan.

Three M.S. theses and four papers have been prepared from this project.



# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 62

CLARK, J.A.

Michigan - Calvin College, Grand Rapids  
Dept. of Geology

## VERTICAL CRUSTAL MOVEMENTS AND STRESSES INDUCED BY GLACIAL ISOSTASY IN THE GREAT LAKES

Starting date:

Completion date: Continuing

Project no:

Sponsor: Sponsor Not Known

AREA: Great Lakes

### KEYWORDS:

geology, glacial, historical

### DESCRIPTION:

Glacio-isostatic uplift in the Great Lakes region has caused considerable tilt of ancient shorelines in the northern portions of the basins. Apparent horizontality of these shorelines to the south, especially in the Lake Michigan basin, suggests crustal stability there during postglacial times. Tilting is also reflected in data from lake level gauges indicating glacio-isostatic movement is continuing at present, however these data suggest that tilting is not only occurring in the northern regions but also in the southern "stable" regions. Predictions of a numerical model of the glacio-isostatic process, assuming a spherical viscoelastic earth with a realistic ice sheet history, fit well the northern tilted shorelines. Predictions also suggest that the southern "stable" regions might be dynamic with present vertical rate of movement up to 2 mm/yr. Large horizontal compressional stresses, perhaps up to 10 MPa, are predicted for the Great Lakes region during the glacial maxima and isostasy induced stresses may be as high as 3 MPa at present. South of the Great Lakes region tensional stresses are predicted to be of comparable magnitude. It is likely that these stresses contribute to the seismicity of the Great Lakes region.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 63

CLARK, P.

Illinois - University of Illinois-Chicago

LATE PLEISTOCENE STRATIGRAPHY OF LAKE MICHIGAN  
COASTAL BLUFF, FORT SHERIDAN, ILLINOIS

Starting date:

Completion date: Continuing

Project no:

Sponsor: Sponsor Not Known

AREA: Southern Lake Michigan; Illinois shoreline; Fort  
Sheridan

KEYWORDS:

geology, lake stages, glacial, historical,  
stratigraphy, sediments, bluffs, sedimentology,  
sediment cores

DESCRIPTION:

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 64

CLARK, T.; NORSTROM, R.J.

Quebec - Canadian Wildlife Service,  
Environment Canada, Hull, Quebec, Canada K1A 0E7

AN ORGANOCHLORINE BIOACCUMULATION DYNAMICS MODEL  
FOR FREE-LIVING HERRING GULLS IN THE GREAT LAKES

Starting date: 4/1986

Completion date: 3/1988

Project no:

Sponsor: Environment Canada; Wildlife Toxicology Fund

AREA: Lake Michigan; Lake Superior; Lake Huron; Lake Erie;  
Lake Ontario

KEYWORDS:

biology, herring gulls, gulls, birds, toxics, organics,  
model, contaminants, eggs, bioaccumulation, physiology,  
diet, food chain, lipids, mirex, dieldrin, DDD, loading,  
organochlorine pesticides

DESCRIPTION:

A large data base exists on organochlorine  
residue levels in herring gull eggs in the Great Lakes.  
A mathematical model of bioaccumulation has been  
developed to analyze trends in loadings to the  
Great Lakes from this data.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 65

COHEN, D.A.; SHEDLOCK, R.J.

Indiana - U.S. Geological Survey, Indianapolis

HYDROLOGY OF THE COWLES BOG WETLAND COMPLEX,  
INDIANA DUNES NATIONAL LAKESHORE

Starting date: 3/1981

Completion date: 9/1985

Project no: IN 81-081

Sponsor: National Park Service

AREA: Indiana; Southern Lake Michigan; Indiana Dunes National  
Lakeshore; Cowles Bog

KEYWORDS:

geology, groundwater, hydrology, wetlands, bog, aquifer,  
water quality, sediments, sand dunes, hydraulic  
properties, chemistry

DESCRIPTION:

Problem:

The hydrology and water quality of the Cowles Bog Wetland Complex and surrounding area are not well understood.

A better understanding will enable the National Park Service to better manage this area of the Indiana Dunes National Lakeshore.

Objective:

To better define the hydrology and hydrochemistry of the unconsolidated aquifer system and the wetland; and the interaction between the groundwater and the surface water in and near the Cowles Bog Wetland Complex.

Approach:

The hydrology and water quality of the area will be defined by: mapping the aquifer and non-aquifer units; defining their hydraulic properties; mapping the potentiometric surfaces of the aquifers; defining the areal, vertical, and temporal variations in water quality in the area; and investigating the storage properties of the wetland and the hydraulic properties of the bottom sediments in the wetland.

Results:

Three reports have been prepared and submitted for review.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 66

COHEN, D.A.; SHEDLOCK, R.J.

Indiana - U.S. Geological Survey, Indianapolis

SHALLOW GROUNDWATER FLOW AND STREAM-AQUIFER RELATIONS  
IN THE GREAT MARSH WETLANDS, INDIANA DUNES NATIONAL LAKESHORE

Starting date: 10/1983

Completion date: 9/1987

Project no: IN 84-087

Sponsor: National Park Service

AREA: Indiana; Southern Lake Michigan; Great Marsh Wetlands;  
Indiana Dunes National Lakeshore

KEYWORDS:

geology, groundwater, hydrology, sand dunes, wetlands,  
hydrography, peat, sediments, aquifer, stratigraphy,  
sedimentology, water table, model, hydraulic properties,  
lake levels, chemistry, water quality, sediment cores,  
mapping, tributaries

DESCRIPTION:

Problem:

Indiana Dunes National Lakeshore extends from Michigan City to Gary, Indiana, along the urbanized and industrialized south shoreline of Lake Michigan. Most of the lowlands between and amongst several sets of ancient dune complexes are wetlands which have been partially drained by ditch systems constructed before the Lakeshore was established in 1966. For management of the wetland ecosystems, the Park Service needs a better understanding of the hydraulic relationship amongst the ditches, the shallow groundwater flow systems, and saturated levels in the organic sediments of the wetlands.

Objective:

In general, to develop a more detailed understanding of shallow groundwater flow and stream-aquifer relations in the Great Marsh, the largest interdunal wetland in Indiana Dunes National Lakeshore, by determining the following:

(1) Stratigraphy and sedimentology of the upper 30 ft. of unconsolidated sediments including the thickness and character of the organic sediments. (2) Bottom characteristics, streambed profiles, stage profiles, and adjacent water-table profiles for streams and ditches in the Great Marsh.

(3) Significance and variation in the vertical movement of water between the organic and mineral sediments.

Approach:

The stratigraphy and sedimentology of the lacustrine and

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

wetland deposits are being studied by a student at Indiana University for his doctoral dissertation. Stream-aquifer relations will be determined by measuring streambed and stage profiles, monitoring water-table fluctuations in response to stream stage changes and precipitation events, and by sampling bottom materials to determine if streams penetrate below the organic sediments. The hydraulic properties of the peat and lacustrine deposits will be investigated using a layered digital flow model. The model will be used to estimate changes caused by change in stream stage and Lake Michigan levels.

### Results:

Stratigraphic information from 34 additional shallow sediment cores along transects through the Great Marsh defined the bottom of the surficial aquifer and produced a map of the top of the till sheet underlying the Great Marsh. Hydrographs and a water-table profile perpendicular to the north edge of the Great Marsh showed the growth and decay of transient water-table mounds in October and December of 1984. Water-level data also showed the crest of the water table mound in the shoreline dune ridge is closer to the dune-wetland margin than originally thought. Chemical analyses of surface and groundwater samples and peat pore fluids in the Great Marsh indicate that upward leakage from the subfill aquifer is occurring and may be a significant portion of the overall water budget for the Great Marsh. Soil coring at 26 sites generally showed 0-3 ft. of peat over most of the Great Marsh. However, peat thickness greater than 9 1/2 ft. were found in portions of the northern third of the Great Marsh. Low water-table conditions in the Great Marsh coupled with record high levels of Lake Michigan indicate there is no short-term correlation between water levels in the Great Marsh and the stage of Lake Michigan. Plans call for an isopach map of the peat in the Great Marsh to be constructed. Water-table profiles along 2 transects equipped with digital recorders will be drawn for recharge and pre-event conditions. Water-quality sampling will be performed along 2 transects during low water-table conditions and after the spring recharge. An areal multi-layered flow model will be constructed for the Derby Ditch drainage basin in the Great Marsh.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 67

COLE, K.

Indiana - Indiana Dunes National Lakeshore, Porter

LATE HOLOCENE DUNE FORMATION, EROSION, AND  
DEVELOPMENT ALONG THE SOUTH SHORE OF LAKE MICHIGAN

Starting date:

Completion date: Continuing

Project no:

Sponsor: Sponsor Not Known

AREA: Southern Lake Michigan; Indiana Dunes State Park; Cowles  
Bog

KEYWORDS:

geology, lake stages, glacial, historical, sediments,  
Holocene, sand dunes, erosion, vegetation, succession,  
stratigraphy, pollen, botany, wetlands, inorganics,  
heavy metals, sediment cores, lake levels

DESCRIPTION:

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 68

COLLINSON, C.

Illinois - Illinois State Geological Survey, Champaign  
Stratigraphy and Surficial Geology Section

## EMERGENCY RESPONSE TO SHORELINE EROSION ALONG ILLINOIS SHORE OF LAKE MICHIGAN

Starting date: 2/01/1986

Completion date: 6/30/1987

Project no:

Sponsor: Illinois Dept. of Energy and Natural Resources

AREA: Illinois shoreline of Lake Michigan

### KEYWORDS:

geology, erosion, bluffs, shoreline, mapping, beach,  
lake levels, aerial photography, coastal structures

### DESCRIPTION:

#### Objectives:

- (1) Do site visits and aerial photography along the entire shoreline of Illinois to determine the changes caused by high lake levels
- (2) Compile a computerized listing of all properties and the status of their beaches and bluffs and protective structures
- (3) Make recommendations for revising protective structure guidelines

#### Results:

This project has produced a computerized inventory of 563 shore parcels which records location, stability, shore protection, and in some cases, protective structure costs. This is being used to update the ISGS Coastal Atlas of the Lake Michigan Shoreline of Illinois. Additional funding in 1987 allowed for a review of storm effects and and an estimation of damage costs.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 70

COLLINSON, C.; HOLM, N.P.; NORBY, R.

Illinois - Illinois State Geological Survey, Champaign  
Stratigraphy and Surficial Geology Section

THE ROLE OF SILURIAN BEDROCK REEFS IN THE LAKE MICHIGAN  
LAKE TROUT FISHERY

Starting date: 6/01/1986

Completion date: 6/30/1987

Project no: F-54-R

Sponsor: Illinois Dept. of Conservation

AREA: Illinois waters of Lake Michigan; Julian's Reef;  
Wilmette Reef

KEYWORDS:

geology, substrate, rehabilitation, lake trout, fish, spawning,  
hydrography, habitat, reefs, mapping

DESCRIPTION:

Objectives:

1. Determine the substrate types and their distribution on Julian's Reef and Wilmette Reef in southern Lake Michigan using geophysical soundings, sediment sampling, and underwater photography.
2. Define, locate, and determine which areas of the reefs would be most suitable for planting lake trout and for examining for the presence of lake trout eggs and fry.
3. Prepare maps of substrate type and hydrography for each of the reefs.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 69

COLLINSON, C.

Illinois - Illinois State Geological Survey, Champaign  
Stratigraphy and Surficial Geology Section

LITTORAL DRIFT BUDGETS FOR THE ILLINOIS LAKE MICHIGAN SHORE

Starting date: 5/01/1987

Completion date: Continuing

Project no:

Sponsor: Illinois Division of Water Resources

AREA: Illinois shoreline of Lake Michigan

KEYWORDS:

geology, sediments, littoral drift, sediment transport,  
beach, currents, hydrography, geophysical

DESCRIPTION:

A long-term cooperative study of littoral drift systems and coarse sediment beach systems has been initiated. More than 40 nearshore profiles for measuring littoral drift were acquired this year. This study will also be coordinated with a joint effort of the ISGS-USGS on a hydrographic/geophysical survey of the Illinois shoreline.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 71

CONLEY, D.J.; QUIGLEY, M.A.; SCHELSKE, C.  
Michigan - University of Michigan, Ann Arbor  
Great Lakes Research Division;  
Michigan - NOAA/GLERL, Ann Arbor;  
Michigan - University of Michigan, Ann Arbor  
Great Lakes Research Division

SILICA AND PHOSPHORUS FLUX FROM SEDIMENTS: IMPORTANCE OF  
INTERNAL RECYCLING TO PRIMARY PRODUCTION IN LAKE MICHIGAN

Starting date: 5/1984  
Completion date: 5/1986  
Project no:  
Sponsor: None

AREA: Green Bay; Lake Michigan

KEYWORDS:

geology, chemistry, geochemistry, nutrients, silica,  
phosphorus, inorganics, sediments, flux, regeneration, diatoms,  
dissolution, model, sediment cores, phytoplankton, cycling

DESCRIPTION:

Dissolved silica (Si) and soluble reactive phosphorus (SRP) fluxes from Lake Michigan sediments were measured through the incubation of intact sediment cores. Si fluxes were three orders of magnitude larger than SRP fluxes. The flux of Si from sediments can supply from 20-40% of the annual diatom production, whereas the annual phosphorus (P) utilization for phytoplankton production is two orders of magnitude greater than inputs from the sediments. Comparison of sediment fluxes to other internal sources of nutrients demonstrates that sediment fluxes are more important in the internal cycling of Si than P. The results show that because of differences in rates of internal recycling small enrichments of P can have a large effect on Si dynamics.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 72

CONLEY, D.J.; SCHELSKE, C.

Michigan - University of Michigan, Ann Arbor  
Great Lakes Research Division

MECHANISMS OF SILICA FLUX FROM THE SEDIMENTS  
OF LAKE MICHIGAN

Starting date: 5/1982  
Completion date: 10/1986  
Project no:  
Sponsor: None

AREA: Lake Michigan

KEYWORDS:

model, chemistry, silica, sediments, nutrients,  
geochemistry, flux, sediment cores, porewater,  
geology, inorganics, remineralization

DESCRIPTION:

The flux of dissolved silica has been determined from cores collected from a variety of sediment types. The predicted flux of silica calculated from pore water silica gradients was only 5-87% of that measured directly by the incubation of intact sediment cores and overlying water. Silica fluxes were poorly correlated with benthic organism density. However, a significant linear relationship was obtained between surficial sediment biogenic silica concentration and silica flux. Additional experiments corroborate that in situ fluxes result from remineralization of recently deposited biogenic silica in surficial sediments. Mass balance calculations indicate that storage of biogenic silica occurred in these areas.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 73

CONLEY, D.J.; SCHELSKE, C.; DEMPSEY, B.G.;  
CAMPBELL, C.D.; NEWBERRY, T.L.

Michigan - University of Michigan, Ann Arbor  
Great Lakes Research Division

## DISTRIBUTION OF BIOGENIC SILICA IN THE SURFICIAL SEDIMENTS OF LAKE MICHIGAN

Starting date: 10/1981  
Completion date: 10/1985  
Project no:  
Sponsor: None

AREA: Lake Michigan; Green Bay

### KEYWORDS:

chemistry, geology, geochemistry, nutrients, silica,  
sediments, inorganics, deposition, sedimentation,  
diatoms, phytoplankton

### DESCRIPTION:

The spatial distribution of biogenic silica (BSi) in the surficial sediments of Lake Michigan is described from Shipek grab samples collected in 1975 and gravity cores obtained in 1983. Significantly smaller surficial BSi concentrations in the 1975 samples were attributed primarily to the inability of a Shipek grab to collect intact surficial sediment samples. Lower concentrations of BSi were found in non-depositional and transitional areas of sediment accumulation than in depositional basins. Therefore, BSi accumulation is restricted to primarily the 40% of the lake bottom where sediments are primarily accumulating. High concentrations found in Green Bay surficial sediments are related to high productivity in the bay coupled with inputs of new silica from the Fox River. In the open lake BSi concentrations of surficial sediments in depositional basins appeared to vary inversely with sedimentation rate in that lower BSi concentrations were found in areas with higher sedimentation rates.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 74

COPES, F.; COBLE, D.

Wisconsin - University of Wisconsin-Stevens Point  
Biology Dept.;

Wisconsin - University of Wisconsin-Stevens Point  
Wis. Coop. Fish Res. Unit

## VITAL STATISTICS AND POPULATION STRUCTURE OF AGE I, II AND III LAKE WHITEFISH IN GREEN BAY AND NORTHERN LAKE MICHIGAN

Starting date: 9/01/1980

Completion date: 8/31/1984

Project no: R/GB-14

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Green Bay; Northern Lake Michigan

### KEYWORDS:

fish, biology, whitefish, populations, mortality,  
age, recruitment, movement, yield, model

### DESCRIPTION:

#### Objectives:

To analyze the vital statistics of age I, II, and III whitefish in Green Bay and northern Lake Michigan waters and this fishery's relationship to the northern Lake Michigan whitefish fishery. Specifically: (1) estimate stock size and analyze age and population structure, movement, and recruitment and contribution to future fishery; (2) design a sampling program and models to predict optimum harvest rates and yield; (3) estimate yields and effects on biomass of various management alternatives.

#### Rationale:

Whitefish is the most important commercial fish species in Lake Michigan in both Wisconsin and Michigan. Over 1 million pounds were harvested from Wisconsin waters in 1981. But little is known about whitefish populations and sustainable yields. This project was initiated in response to requests by the commercial fishermen and the natural resources agencies of both states.

#### Accomplishments:

Found movement patterns of juvenile whitefish similar to those of adults and exploitation rate (survival/mortality) fairly constant in last three years. Michigan and Wisconsin DNRs are using project information in managing northern Lake Michigan whitefish fishery. Commercial fisherman's financial support increased to over \$30,000 in 1983. Several are using recommended sites and accepting recommended changes to reduce fishing mortality in stocks.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 75

COPESE, F.; COBLE, D.

Wisconsin - University of Wisconsin-Stevens Point  
Biology Dept.;

Wisconsin - University of Wisconsin-Stevens Point  
Wis. Coop. Fish. Res. Unit

THE DROP NET FISHERY AND ITS EFFECTS ON YELLOW  
PERCH YIELDS IN GREEN BAY

Starting date: 9/01/1982

Completion date: 8/31/1985

Project no: R/GB-17

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Green Bay; Lake Michigan

KEYWORDS:

commercial fishing, fish, yellow perch,  
survival, mortality, biology, management

DESCRIPTION:

Objectives:

The overall objective is to reduce the mortality of sublegal yellow perch caught in commercial drop nets in Green Bay. Specifically: (1) determine the proportion of legal and sublegal yellow perch that die in commercial dropnets; (2) estimate short-term handling mortality of sublegal yellow perch; (3) determine the effect of holding time in the net on survival; (4) identify net modifications that will enable sublegal fish to escape while retaining legal-size perch.

Rationale:

Yellow perch provide a substantial sport fishery and an intense commercial fishery on Green Bay, but annual mortality is high. About half the perch taken in commercial drop nets are sublegal-size, and apparently many of these die after culling. This study is aimed at reducing perch mortality, improving drop net efficiency and increasing sport and commercial perch yields.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 76

COPES, F.; COBLE, D.

Wisconsin - University of Wisconsin-Stevens Point  
Biology Dept.

Wisconsin - University of Wisconsin-Stevens Point  
Wis. Coop. Fish. Research Unit

POPULATION MODELING OF LAKE WHITEFISH IN GREEN BAY  
AND WISCONSIN WATERS OF LAKE MICHIGAN AND MODEL  
VERIFICATION

Starting date: 9/01/1984

Completion date: 8/31/1986

Project no: R/GB-23

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Wisconsin waters of Lake Michigan; Green Bay

KEYWORDS:

model, commercial fishing, biology, whitefish, fish,  
year-class strength, growth, mortality, recruitment,  
yield, populations

DESCRIPTION:

Objectives:

To analyze the population statistics of lake whitefish with emphasis on estimating population size and biomass, year-class strength, instantaneous growth and mortality rates (natural, gill net, pound net, trap net); design a sampling program and models using prerecruitment and recruitment catch to predict the optimum harvest rates and yield; analyze trap net mortality; complete and validate population models that will have predictive capability; develop a stock-recruitment model.

Methodology:

Fish trap and pound nets; sample commercial catch; tag and release sublegals, weigh a stratified sample; take scale samples; offer reward for tag returns; use Deriso, Regression, Cohort, Catch at Age, Ricker and other computer models.

Rationale:

Whitefish is the most important commercial fish species in Lake Michigan; a predictive whitefish management plan for the lake is needed. This project is proposed in direct response to requests from commercial fishermen and departments of natural resources. The population model and analysis will be incorporated in whitefish management plans for this resource.

Accomplishments:

In 1985, tagged and tracked movements of sublegal whitefish (age I and II); investigated their mortality in trap nets;

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

examined 20 environmental factors and ways fishermen handled their nets and fish as relative factors in fish mortality; worked on tag returns to see shifts in mortality by total fishing industry and by specific gear--trap net, gill net, pound net, trawl net. Attempted to verify earlier models on whitefish developed by this project and by the Michigan D.N.R. and the tribal fisheries. Three M.S. theses have been completed in connection with this project.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 77

COPES, F.; COBLE, D.

Wisconsin - University of Wisconsin-Stevens Point  
Biology Dept.;

Wisconsin - University of Wisconsin-Stevens Point  
Wis. Coop. Fish. Res. Unit

TROPHIC ECOLOGY AND POPULATION STATISTICS OF BURBOT,  
LOTA LOTA, IN GREEN BAY AND LAKE MICHIGAN

Starting date: 9/01/1986

Completion date: 8/31/1989

Project no: R/LR-36

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Western Lake Michigan; Green Bay

## KEYWORDS:

biology, fish, burbot, lake trout, walleye,  
age, growth, diet, seasonal, populations

## DESCRIPTION:

The burbot populations in Green Bay and in Lake Michigan are burgeoning and have the potential of becoming an important commercial fishery. This project is assembling the basic biological information about the burbot needed to assess its role in the lake ecosystem and whether a large burbot population might adversely affect other fish populations. This information will aid in the development of a model of the Green Bay fish community and its food web, which will enable fishery agencies to develop a burbot management plan for the lake and improve management of the bay's other fisheries as well.

Burbot, lake trout, walleye, and other fish species will be collected at various sites during each of the four seasons for comparison of their diet. Age and growth will be measured on the fish species.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 78

CROLEY, T.E.

Michigan - NOAA/GLERL, Ann Arbor

## GREAT LAKES BASINS RUNOFF MODELING

Starting date: 6/1983

Completion date: 9/1986

Project no: Task 7.7

Sponsor: NOAA

AREA: Lake Superior; Lake Michigan; Lake Huron; Lake Erie;  
Lake Ontario; Great Lakes Basin

### KEYWORDS:

model, hydrology, runoff, climate, watershed, physical,  
water quality, precipitation, rain, snow, meteorology,  
tributaries, watershed

### DESCRIPTION:

#### Objectives:

- (1) To develop digital models that will simulate runoff responses of each of the Great Lakes Basins to time series of climatological conditions and simulate the hydrologic response of individual watersheds in the Great Lakes Region reasonably accurately.
- (2) To interface the lake basin watershed models with the Great Lakes Hydrologic Response Model so that the watershed models provide the runoff component to the response model.

#### Results:

During the initial phases of this study, two existing models were evaluated for simulating the detailed hydrologic response of individual watersheds. The Corps of Engineers Streamflow Synthesis and Reservoir Regulation Model (SSARR) and the National Weather Service Hydrologic Model (NWSH) were evaluated in terms of reproducing volumes of runoff from the Genesee River Basin, N.Y. The SSARR model was then used to simulate runoff from the Southeast Lake Michigan drainage basin. Runoff was successfully hindcast for 6-mo periods in years with high, low, and ave. runoff from long-term monthly precipitation. Although the model shows potential for use in simulating or forecasting runoff into the Great Lakes, its economic effectiveness depends on the ability to group watersheds of similar hydrologic characteristics into a single regional equivalent watershed.

A simpler model was developed which is physically based and uses readily available data. Referred to herein as the GLERL Large Basin Runoff Model (LBRM), it accounts for the

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

processes of snow accumulation/melt, evapotranspiration, infiltration, surface storage, upper, lower, and groundwater zone moisture storages, and flows from these storages. The model was developed on the Genesee River Basin, adjacent to Lake Ontario and a calibration procedure was also developed.

Comparisons of the GLERL Large Basin Runoff Model with the SSARR and NWSH models are complete. The GLERL model proved to be an accurate, fast model with relatively simple calibration and data requirements for large watersheds. The model has been applied to numerous subbasins around Lake Superior and Lake Michigan. Calibrations on a daily basis are currently underway for Lakes Michigan, Huron, Erie, and are planned for Lakes St. Clair and Ontario. A number of papers and presentations have been prepared from this project.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 79

CROLEY, T.E.

Michigan - NOAA/GLERL, Ann Arbor

GLERL-SEA COOPERATIVE EFFORT: UPLAND EROSION  
IN THE GREAT LAKES BASIN

Starting date: 1981  
Completion date: 12/1984  
Project no: Task 7.14  
Sponsor: NOAA

AREA: Great Lakes Basin

KEYWORDS:

model, physical, erosion, watershed, pollution,  
deposition, transport, sediments, nonpoint source,  
water quality, geology

DESCRIPTION:

The physical processes of upland erosion and degradation are poorly understood; knowledge of these processes would be useful to watershed and pollutant modelers for alleviation of dredging requirements in harbors, for understanding the mechanics of various nonpoint-source pollutants, and for understanding similar processes such as wind erosion and sediment transport. During the past 4 years, GLERL has collaborated with the U.S. Dept. of Agriculture's Science Education Administration on the design of necessary experiments for testing recently developed mathematical-physical models of upland entrainment, deposition, and transport. These experiments were made in August and September 1981 and July 1982 in cooperation with Purdue University's Agricultural Engineering Dept. Problems associated with deposition during hydrograph recession were encountered in the 1981 experiments and eliminated in the 1982 experiments. Sufficient data were obtained to investigate validity, to promote extensions of the basic concepts, and to suggest further experiments for testing the basic concepts and for investigating the underlying physics.

Unsteady overland sedimentation in rills can be described with kinematic flow and sediment continuity equations. The uniform flow approximation requires the use of parameters not in agreement with sheet flow or channel flow experience; but the parameters are in agreement with the unsteady channel cross section expected during the erosion process. Physically-based models of upland erosion (detachment, deposition, and transport) are now available.

Five publications have been prepared from the results of this project.



# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 80

CROLEY, T.E.

Michigan - NOAA/GLERL, Ann Arbor

## GREAT LAKES HYDROLOGICAL FORECASTING

Starting date: 1/1984  
Completion date: 12/1987  
Project no: Task 7.17  
Sponsor: NOAA

AREA: Lake Superior; Lake Michigan; Lake Huron; Lake Erie;  
Lake Ontario; Great Lakes Basin

### KEYWORDS:

model, physical, hydrology, water supply,  
runoff, lake levels, database, rain, meteorology,  
precipitation, evaporation, temperature, watershed,  
tributaries

### DESCRIPTION:

#### Objectives:

- (1) To develop digital models for making deterministic and probabilistic forecasts of soil moisture, runoff, net basin supply, and lake levels in near real-time for the Great Lakes Basins.
- (2) To develop and maintain a hydrologic data base in a near real-time fashion of sufficient quality for scientific and water resources studies and for up-to-date forecasts and outlooks.
- (3) To investigate use of system-wide forecasting in lake-level regulation determination.

#### Results:

A conceptual rainfall-runoff model has been calibrated for the Lakes Ontario, Champlain, and Superior Basins and will soon be in place for the Lakes Michigan, Huron, Erie, and St. Clair Basins. The model is an interdependent tank-cascade concept of basin runoff; it employs analytical solutions of climatological considerations relevant for large watersheds. Effective operational forecasts of soil moisture, basin runoff, net basin supply, and lake levels require meteorological data to be available for use by the conceptual models in near real-time. The timeliness of data availability affects the usefulness of the forecasts. The experimental near real-time data acquisition network is being designed for an eventual delay of only one week between the time the data is measured in the field and when it is available for use by the conceptual models. The need for efficient computations of daily average precipitation and minimum/maximum temperatures over each of the many subbasins



## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

about a lake from the station values in the data network required the development of a new algorithm for computing Thiessen weights. The Thiessen-weighting algorithm was used under Task 7.7 to redesign software for the reduction of meteorological data into climatological subbasin data sets. The algorithm was incorporated into the development of software for the semi-automatic update of the provisional data bases and for the semi-automatic generation of deterministic or probabilistic forecasts.

A number of papers and presentations have been prepared from this project.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 81

CROLEY, T.E.

Michigan - NOAA/GLERL, Ann Arbor

ESTIMATION OF OVERLAKE EVAPORATION ON THE GREAT LAKES

Starting date: 1987

Completion date: Continuing

Project no: Task 7.25

Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

physical, evaporation, temperature, water budget,  
meteorology

DESCRIPTION:

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 82

CROLEY, T.E.; FONTAINE, T.D.; HARTMANN, H.C.  
Michigan - NOAA/GLERL, Ann Arbor

MULTIOBJECTIVE BASIN-WIDE MODELS FOR GREAT LAKES  
WATER QUANTITY AND QUALITY MANAGEMENT

Starting date: 1986  
Completion date: Continuing  
Project no: Task 9.27  
Sponsor: NOAA

AREA: Great Lakes Basin

KEYWORDS:

physical, management, model, water quality, water quantity,  
diversion, evaporation, runoff, watershed, water use,  
lake levels, climate, precipitation, groundwater, hydrology,  
loading, transport

DESCRIPTION:

Objectives:

- (1) To develop the capability for basin-wide assessment of major new diversions, increased consumptive uses, lake-level regulations, and climatic change.
- (2) To coordinate water quantity conceptual models of rainfall-runoff, lake evaporation and precipitation, groundwater, and channel hydraulics with conceptual models of ecosystem function, contaminant transport, and lake economics.
- (3) To develop simulation models from (2), above, for basin-wide simulations of water quantity and quality.
- (4) To identify use objectives from basin-wide, state, national, and international Great Lakes perspectives.
- (5) To identify views, attitudes, and value functions associated with the use objectives and to integrate them into the water quantity/quality models.
- (6) To adapt optimization methodologies for identification of efficient management alternatives.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 331

DAVENPORT, R.; SPACIE, A.

Illinois - University of Illinois, Champaign-Urbana

Dept. of Genetics and Development

Indiana - Purdue University, West Lafayette

Dept. of Forestry and Natural Resources

## LIGHT, WATER AND THE PHOTOINDUCED TOXICITY OF COMPLEX MIXTURES OF HYDROCARBON POLLUTANTS

Starting date: 5/01/1987

Completion date: 4/30/1989

Project no: R/F-10

Sponsor: Illinois/Indiana Sea Grant Program

AREA: Southern Lake Michigan

### KEYWORDS:

chemistry, toxics, organics, bioassay, PAHS, irradiance, sunlight, synergism, sediments, photochemistry, fish, Daphnia, Cladocera, zooplankton, bacteria, genetics

### DESCRIPTION:

#### Objectives:

To investigate the light-induction of toxicants from existing hydrocarbon pollutants in Southern Lake Michigan.

#### Methodology:

The existing toxicity as mutagenicity of water and sediments will be tested using ultrasensitive techniques both before and after radiation with near-ultraviolet light. Products of radiation will be partially fractionated and characterized.

#### Rationale:

The near-UV component of sunlight can produce soluble and highly toxic products. The Great Lakes contain reservoirs of such hydrocarbons and these have never been examined for their hydrocarbic potential.

#### Accomplishments:

This research will provide an initial database for the evaluation of potential phototoxic damage to the environment and will provide a foundation for future research.

#### Benefits:

This work will fill a gap in the understanding of environmental damage caused by hydrocarbon pollution and it will aid in making decisions as to future disturbances of bottom sediments in Southern Lake Michigan.

Ref. no. 83

DAY, H.J.; LEE, K.

Wisconsin - University of Wisconsin-Green Bay  
Science and Environmental Change;

Wisconsin - University of Wisconsin-Milwaukee  
Civil Engineering

HYDRODYNAMIC AND WATER QUALITY MODELING FOR LOWER  
GREEN BAY

Starting date: 9/01/1982

Completion date: 8/31/1984

Project no: R/GB-19

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Green Bay; Fox River; Lake Michigan

KEYWORDS:

model, physical processes, water quality, wastewater,  
loading, river, currents, pollution, discharge,  
circulation, chemistry

DESCRIPTION:

Objectives:

To adapt, calibrate and verify hydrodynamic and water quality models for the lower Fox River and lower Green Bay. Specifically: (1) to organize and coordinate a field data collection program; (2) to adapt Milwaukee Harbor models to Green Bay; (3) to use field data collected above in calibrating and verifying the models; (4) to assist project participants in applying the model.

Rationale:

Pending wasteload allocations being developed by the Wisconsin Dept. of Natural Resources could be very costly to Green Bay and urban Brown County citizens and industries. Hydrodynamic and water quality models for the lower Fox River and lower Green Bay would help ensure that the most cost-effective allocation plan is considered.

Accomplishments:

Adapted and calibrated a model of water quality and water movement in Green Bay for use in wastewater allocation problems. The Wisconsin DNR, which worked with the investigators, plans to use the model in its wastewater allocations. The Corps of Engineers is considering using it for studies of dredge spoil disposal sites.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 84

DOBOS, R.; WESELOH, D.V.; BIDER, J.

Ontario - Canadian Wildlife Service, Burlington

DISTRIBUTION OF WATERBIRDS ON THE GREAT LAKES  
IN EARLY WINTER

Starting date: 1976

Completion date: 1985

Project no:

Sponsor: Canadian Wildlife Service

AREA: Lake Superior; Lake Michigan; Lake Huron; Lake Erie;  
Lake Michigan; connecting channels

KEYWORDS:

biology, birds, waterbirds, gulls, ducks, herons,  
mergansers, loons, abundance, winter, populations,  
distribution

DESCRIPTION:

Data from 563 Christmas Bird Counts conducted on the Great Lakes from 1976-85 were summarized for waterbirds (i.e. loons, herons, waterfowl, gulls, etc.) to provide a directory of waterbird distribution on the Great Lakes during early winter. A total of 120 species was recorded on the five lakes and connecting rivers. Survey effort varied greatly among the lakes (2500-11,000 hr./lake). The number of species/1000 party hrs. was greater (21.4) on the river systems than on any of the lakes (range: 6.5-11.0). Waterbird abundance also varied greatly among lakes. The number of individuals recorded/party hr. ranged from 12 on L. Superior to 338 on L. Erie. Ring-billed and Herring Gulls, Mallard, Canvasback and Common Merganser were the most abundant species on each lake/river, although abundance varied among sites. The directory is an extremely useful tool for plotting waterbird distribution on the Great Lakes in early winter.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 85

DORAZIO, R.M.; BOWERS, J.; LEHMAN, J.  
Michigan - University of Michigan, Ann Arbor  
Division of Biological Sciences and  
Great Lakes Research Division

FOOD LIMITATION AND PATTERNS OF RESOURCE UTILIZATION BY  
DAPHNIA AND DIAPTOMUS IN LAKE MICHIGAN

Starting date: 1985  
Completion date: Continuing  
Project no:  
Sponsor: National Science Foundation

AREA: Lake Michigan

KEYWORDS:

biology, zooplankton, diet, competition, populations,  
Cladocera, Copepoda, chlorophyll, feeding,  
phytoplankton, zooplankton grazing

DESCRIPTION:

Objectives:

Determine if observed changes in zooplankton community  
from Diaptomus- to Daphnia-dominated assemblages were  
related to changes in availability of food resources.

Methodology:

Experimentally measure size- and species-specific  
productivity of Daphnia and Diaptomus incubated at different  
concentrations of Lake Michigan phytoplankton. Also measure  
ingestion rates of these zooplankton species on different size  
fractions of algae.

Results:

Experiments reveal differences in the ways that Daphnia and  
Diaptomus exploit scarce food resources.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 86

EADIE, B.J.

Michigan - NOAA/GLERL, Ann Arbor

POLYNUCLEAR AROMATIC HYDROCARBONS IN THE  
GREAT LAKES ECOSYSTEM

Starting date:

Completion date: Continuing

Project no: Task 4.1

Sponsor: NOAA

AREA: Great Lakes; Lake Michigan

KEYWORDS:

chemistry, model, analytical methods, PAHs, water quality,  
organics, toxics

DESCRIPTION:

Objectives:

- (1) To develop analytical capability to accurately quantitate selected PAHs in different parts of the Great Lakes.
- (2) To quantify the levels of selected PAHs in parts of the Great Lakes ecosystem.
- (3) To calibrate a first-order assessment model for PAH in Lake Michigan.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 87

EADIE, B.J.; MOREHEAD, N.R.

Michigan - NOAA/GLERL, Ann Arbor

PHASE DISTRIBUTION AND SORPTION KINETICS OF  
ORGANIC CONTAMINANTS ON GREAT LAKES PARTICULATE  
MATTER

Starting date: 1984

Completion date: Continuing

Project no: Task 4.9

Sponsor: NOAA

AREA: Lake Michigan; Great Lakes

KEYWORDS:

chemistry, particulates, organics, contaminants, sorption,  
toxics, desorption, transport

DESCRIPTION:

Objectives:

- (1) To measure the equilibrium phase distribution of selected organic compounds in Lake Michigan.
- (2) To identify and quantify the major variables which mediate phase distribution.
- (3) To measure the rates of adsorption and desorption of selected organic compounds with Great Lakes particulate matter.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 88

EADIE, B.J.; MOREHEAD, N.R.; ROBBINS, J.A.  
Michigan - NOAA/GLERL, Ann Arbor

## MULTITRACER-PARTICLE ASSOCIATIONS

Starting date:  
Completion date: 1986  
Project no: Task 3.9  
Sponsor: NOAA

AREA: Lake Michigan

### KEYWORDS:

physical, particulates, tracer, partition coefficients, organics, contaminants, radionuclides, sediments, toxics, organic carbon, desorption, water quality, chemistry

### DESCRIPTION:

#### Objectives:

- (1) To determine the equilibrium distribution (partition) coefficients for organic contaminants and radionuclides onto Lake Michigan particulate matter.
- (2) To determine the dependence of the distribution coefficients on the concentration of solids in sediment-water suspensions.
- (3) To determine the role of dissolved organic carbon on partitioning.
- (4) To determine the effect of prolonged contact of tracers with sediments on the distribution coefficient of desorption.

Ref. no. 89

EADIE, B.J.; ROBBINS, J.A.  
Michigan - NOAA/GLERL, Ann Arbor

TOXIC ORGANIC MODELING IN THE GREAT LAKES

Starting date:  
Completion date: Continuing  
Project no: Task 4.2  
Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

model, organics, chemistry, toxics, contaminants,  
PAHs, PCBs, cycling, research needs, water quality,  
fate, transport

DESCRIPTION:

Objectives:

- (1) To synthesize available information on the aquatic cycling of PCBs and PAHs into a numerical model hierarchy for the Great Lakes ecosystem.
- (2) To aid in the identification of process research needs.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 90

ECK, G.

Michigan - National Fisheries Center - Great Lakes, Ann Arbor

## MORTALITY OF PRERECRUIT LAKE TROUT - LAKE MICHIGAN

Starting date: 5/01/1983

Completion date: Continuing

Project no:

Sponsor: U.S. Fish and Wildlife Service

AREA: Lake Michigan - off Holland, Michigan; Michigan waters

### KEYWORDS:

biology, fish, lake trout, mortality, populations,  
stocking, trawling, monitoring, abundance,  
survival, salmonid, life history

### DESCRIPTION:

Lack of accurate estimates of lake trout mortality from time of stocking to age V is a major impediment to projection of absolute sizes of the standing stocks of lake trout planted in the Great Lakes as a basis for evaluating efforts to restore self-sustaining populations. Immature lake trout are only nomially vulnerable to largemesh gillnet conventionally used to capture adults in both experimental and (past) commercial fishing. The overall goal of this work unit is to develop and implement methods on a pilot-test basis for reliably estimating prerecruit mortality. The ongoing field experiment involves systematic sampling each year with wing-trawls for lake trout stocked as a special plant of yearlings in Lake Michigan near Holland, Michigan, in spring 1983; hopefully the resulting data will permit us to segregate temporal effects of dispersal after release from absolute declines in abundances attributable to mortality.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 91

EDGINGTON, D.

Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies

STUDIES OF LIMNOLOGICAL PROCESSES CONTROLLING THE  
AVAILABILITY OF TOXIC SUBSTANCES TO AQUATIC FOOD  
CHAINS IN THE GREAT LAKES

Starting date:

Completion date: Continuing

Project no:

Sponsor: U.S. EPA

AREA: Great Lakes

KEYWORDS:

biology, chemistry, toxics, contaminants, organics,  
food chain, bioaccumulation, diet, sediments,  
resuspension

DESCRIPTION:

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 92

EDGINGTON, D.; ANDREN, A.

Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies;  
Wisconsin - University of Wisconsin-Madison  
Water Chemistry Program

## THE PERSISTENCE OF ORGANIC POLLUTANTS IN A GREAT LAKES ESTUARY

Starting date: 9/01/1986

Completion date: 8/31/1990

Project no: R/GB-25

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Green Bay; Lake Michigan

### KEYWORDS:

chemistry, organics, pollution, transport, fate, sediments,  
atmospheric, PCBs, toxics, biodegradation, PAHs,  
biology, food chain, cycling, flux, wetlands, pattern  
recognition, diagenesis, sediment cores, volatilization

### DESCRIPTION:

#### Objectives:

To (1) investigate if Green Bay is a sink or source of PCBs and PAHs to Lake Michigan; (2) study temporal changes in PCBs and PAHs in Green Bay sediments; (3) investigate the importance of volatilization of PCBs and PAHs from Green Bay; (4) investigate the extent of compound and congener fractionation from source, through the water and sediments, and through the food web in the bay; (5) apply a new pattern recognition framework to analyze data base to understand environmental cycling of PCBs and PAHs.

#### Methodology:

Sediment core and suspended sediment collection;  
radiometric date techniques; high-resolution GC  
and GC-MS analysis; study PCB and PAH volatilization  
using bubble stripping chambers in situ; SIMCA pattern  
recognition technique.

#### Rationale:

Green Bay has been identified as one of the most polluted areas in Lake Michigan, especially with respect to PCBs and PAHs. It is still unknown whether the bay is a permanent or a continuous source of pollutants to Lake Michigan. The rate of volatilization, degradation or permanent burial in this and similar coastal systems needs to be quantified.



# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 93

EDGINGTON, D.; BROOKS, A.;

SEALE, D.B.; BORAAS, M.E.

Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies

## EVALUATING EUTROPHICATION IN LAKE MICHIGAN USING DATA FROM MUNICIPAL WATER INTAKES

Starting date: 4/01/1984

Completion date: 8/31/1986

Project no: R/MW-32-PD

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Lake Michigan

### KEYWORDS:

phytoplankton, botany, biology, chemistry, water quality,  
monitoring, historical, eutrophication, analytical methods,  
silica, phosphorus, nutrients, inorganics

### DESCRIPTION:

#### Objectives:

To (1) convert existing, daily phytoplankton species counts and other limnological data to machine-readable format; (2) analyze the data to determine long-term trends and to test hypotheses concerning species interactions and eutrophication; (3) calibrate the historical data by analyzing lake collected samples and water treatment plant samples collected on the same dates.

#### Methodology:

Enter the historical data into computer files. Use established statistical, graphical, time-series, and signal-flow methods to analyze data. Use conventional limnological procedures to calibrate the historical data to the lake.

#### Rationale:

Long-term, consistent sampling of physical, chemical, and biological variables is essential for understanding and predicting the responses of the Lake Michigan ecosystem. The only useful extant record is that in the Linnwood Plant in Milwaukee. This project will give a biological interpretation of that record and make it available to the research community.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 94

EDGINGTON, D.; CHRISTENSEN, E.

Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies;  
Wisconsin - University of Wisconsin-Milwaukee  
Civil Engineering Dept.

## PERSISTENCE OF POLLUTANTS IN THE SEDIMENTS OF LAKE MICHIGAN'S GREEN BAY

Starting date: 9/01/1981  
Completion date: 8/31/1984  
Project no: R/GB-15  
Sponsor: University of Wisconsin Sea Grant Institute

AREA: Green Bay; Lake Michigan

### KEYWORDS:

trace metals, PCBs, toxics, sediments, flux,  
contaminants, chemistry, water quality, inorganics,  
sediment cores, sedimentation, lead-210, cesium,  
dating, transport, mixing, fate, historical

### DESCRIPTION:

#### Objectives:

(1) Evaluate the sources, transport, and sinks of sediments in Green Bay; (2) determine the extent of biological activity in the sediments; (3) estimate the extent, magnitude and frequency of sediment disturbances by storms; (4) determine the history of inputs and annual fluxes to the sediments of trace organic and inorganic compounds; (5) estimate the importance of the sediments as a sink and the time it will take them to respond to remedial actions like nutrient and contaminant controls.

#### Accomplishments:

Collected and analyzed sediment cores from major sedimentation areas in Green Bay for cesium-137 and lead-210; calculated sedimentation rates and mixing depths. Discontinuities in the lead-210 and porosity profiles and differences in the calculated sedimentation and mixing parameters have provided measurements of sediment disturbances by storms and long-term transport from temporary to permanent sinks, respectively. Measurements of trace metals and PCBs are under way; preliminary estimates can be made of fluxes to the sediments.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 95

EDGINGTON, D.; KLUMP, J.V.; BINKOWSKI, F.P.;  
KASTER, J.L.

Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies

ENVIRONMENTAL EFFECTS AND FEASIBILITY OF FLY ASH  
BLOCK ARTIFICIAL REEF CONSTRUCTION

Starting date: 12/1/1984

Completion date: 12/31/1986

Project no:

Sponsor: Wisconsin Electric Power Co.

AREA: Laboratory

KEYWORDS:

biology, chemistry, fly ash, artificial reefs,  
inorganics, metals, bioassay, toxics, water quality,  
fish, zooplankton, phytoplankton, fathead minnow,  
walleye, lake trout

DESCRIPTION:

These studies are being done to test environmental effects of fly ash blocks on fish, phytoplankton, and zooplankton to determine whether fly ash blocks can be used in artificial reefs in Lake Michigan. This would be an alternative to current disposal practices of coal combustion waste.

Ref. no. 96

EDIL, T.; GREEN, T.; WORTLEY, C.A.

Wisconsin - University of Wisconsin, Madison  
Civil and Environmental Engineering;

Wisconsin - University of Wisconsin, Madison  
Civil and Environmental Engineering

Wisconsin - University of Wisconsin, Madison  
Engineering Professional Development

## THE PULLOUT OF HARBOR PILES BY VERTICAL MOTIONS OF ICE

Starting date: 9/01/1984

Completion date: 8/31/1986

Project no: R/NI-08

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Great Lakes

### KEYWORDS:

waves, harbors, physical, engineering, marinas,  
coastal structures, hydrodynamics, model,  
oscillations, ice

### DESCRIPTION:

#### Objectives:

(1) To provide information for use by dock and harbor designers faced with "ice-jacking" problems; (2) To determine the characteristics of vertical motions of ice in harbors and the effect of these motions on piles; (3) To use such information to improve design criteria for piles in northern harbors and marinas.

#### Methodology:

Use of analytical and numerical models to investigate the character of vertical ice oscillations and the associated lifting force on a pile; laboratory and large-scale model tests; field data (collected by others) to test the results.

#### Rationale:

"Ice-jacking", a common problem in northern harbors, is the phenomenon whereby the continued, small vertical oscillation of the ice in a harbor can pull piles completely out of the bottom over the course of a winter, often resulting in severe damage to docks and other pile-supported structures. These results may also be applicable to other situations involving ice damage.

#### Accomplishments:

Studied a scale model test of the pullout resistance of model piles imbedded in sand and subjected to cyclic

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

loadings, such as transmitted by vertical oscillations of sheets, and found a degradation of the uplift resistance as a result of being subjected to cyclic loads. Now trying to determine the most important factors and general quantitative characteristics of this degradation. This project is continuing and will study pullout resistance of harbor piles to ice forces.

### Benefits:

The potential users are marina designers, dock manufacturers and coastal engineers in northern climates. The investigators are in direct contact with such people by way of consulting and short courses presented annually. The information is also disseminated via user-oriented technical reports such as Wortley (1984).

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 97

EDSALL, T.; BROWN, C.

Michigan - National Fisheries Center - Great Lakes, Ann Arbor

EVALUATION OF LAKE TROUT SPAWNING AND NURSERY  
HABITAT IN GREAT LAKES WATERS

Starting date: 10/1982

Completion date: 9/1988

Project no:

Sponsor: U.S. Fish and Wildlife Service; Great Lakes Fishery  
Commission

AREA: Wilmette Reef, Lake Michigan; Beaver Island area  
(Richard's Reef), Lake Michigan; Port Austin Reef, Lake  
Huron; Partridge Island Reef, Lake Superior; Lake  
Ontario; Lake Erie

KEYWORDS:

biology, lake trout, fish, salmonid, rehabilitation, spawning,  
mapping, substrate, hydrography, habitat, geology, reefs,  
reproduction, photography

DESCRIPTION:

The Great Lakes Fishery Commission has determined that a more systematic approach needs to be taken to understand why lake trout are not successfully reproducing in four of the Great Lakes. The GLFC is sponsoring this project to examine and compare potential spawning reefs in each of the five Great Lakes. Work is currently being done using side scan sonar and a remotely operated underwater television camera to record and classify substrate types at historically productive spawning sites in Lake Huron, Lake Superior, and Lake Michigan. The results of these studies will permit the selection of stocking sites at which planted lake trout will be able to reproduce successfully.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 98

EGERTON, F.

Wisconsin - University of Wisconsin-Parkside, Kenosha  
History of Science and Environmental History

HISTORICAL PERSPECTIVE OF POPULATION FLUCTUATIONS  
IN GREAT LAKES FISH POPULATIONS

Starting date: 9/01/1986

Completion date: 8/31/1988

Project no: R/PS-36

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Lake Michigan; Lake Superior; Lake Huron; Lake Erie;  
Lake Ontario

KEYWORDS:

historical, management, fish, review, populations

DESCRIPTION:

Objectives:

To investigate the pattern of population studies conducted on Great Lakes fish species from the 1950s to the 1980s: Do distinct schools of population studies exist and, if so, where are they? Do the different techniques reflect different criteria for verification? Are there significant disagreements in evaluating evidence and, if not, is consensus attained too easily? What overall advancements in understanding fish population dynamics have occurred on the Great Lakes?

Methodology:

Two sources of information: the published literature and interviews with fishery biologists conducting research on the Great Lakes (the published literature is easily accessible but seldom contains all the relevant judgements of the biologists).

Rationale:

Assessing changes in fish populations is probably the most important task of fishery biologists, and such changes in the Great Lakes have been dramatic. Biologists have made fish life history investigations, commercial catch statistics analyses, computer models and other studies. A general survey of what has been achieved in this area would be useful to fish biologists.



Ref. no. 99

EGERTON, F.

Wisconsin - University of Wisconsin-Parkside, Kenosha  
History of Science and Environmental History

ECOLOGICAL RESEARCH AND THE MANAGEMENT OF THE  
GREAT LAKES FISHERIES FROM ABOUT 1920 TO ABOUT  
1950

Starting date:

Completion date: 1984

Project no: SGA-01

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Lake Michigan; Green Bay; Saginaw Bay; Western Lake  
Erie; Lake Huron

KEYWORDS:

biology, fish, management, historical, populations,  
productivity, policy

DESCRIPTION:

This project has resulted in two publications (one is  
Great Lakes Fishery Commission Technical Report No. 41)  
and a number of presentations.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 100

EISENREICH, S.

Minnesota - University of Minnesota, Minneapolis  
Civil and Mineral Engineering Dept.

TOXIC ORGANIC-SEDIMENT DYNAMICS IN THE GREAT LAKES

Starting date: 1982

Completion date: 1985

Project no:

Sponsor: NOAA/GLERL

AREA: Great Lakes

KEYWORDS:

chemistry, sediments, organics, organochlorine pesticides, PCBs, DDT, mirex, radionuclides, lead-210, dating, BHC, HCB, porewater, sedimentation, sediment cores, toxics, diagenesis, deposition, transport, historical, flux, chlorobenzenes, water quality

DESCRIPTION:

Objective:

To determine the history of deposition and post-depositional mobility and of transformation of organic contaminants in radiometrically characterized sediment cores.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 101

EISENREICH, S.

Minnesota - University of Minnesota, Minneapolis  
Civil and Mineral Engineering Dept.

EVALUATION OF PRECIPITATION SAMPLERS FOR ORGANICS

Starting date: 1985

Completion date: 1986

Project no:

Sponsor: U.S. EPA - Great Lakes National Program Office

AREA: Great Lakes

KEYWORDS:

chemistry, atmospheric, precipitation,  
organics, deposition, sampling

DESCRIPTION:

Ref. no. 102

EVANS, M.S.; MEYERS, P.A.; SIMMONS, M.S.  
Michigan - University of Michigan, Ann Arbor  
Great Lakes Research Division

INCORPORATION, CONCENTRATION, AND EXCHANGE OF LIPOPHILIC  
CONTAMINANTS IN AN AQUATIC ECOSYSTEM

Starting date: 5/01/1986  
Completion date: 11/01/1988  
Project no:  
Sponsor: U.S. EPA

AREA: Lake Michigan; Grand Haven area; Michigan waters

KEYWORDS:

chemistry, organics, toxics, contaminants, PCBs, PAHs,  
DDE, lipids, phytoplankton, zooplankton, benthic,  
invertebrates, Mysis, Amphipoda, sculpin, fish, food chain,  
bioaccumulation, biochemistry, diet, organochlorine  
pesticides

DESCRIPTION:

Objective:

To evaluate relationships between fat-soluble contaminants (PCBs, PAHs, DDE) and lipid content and composition of plankton, mysids, amphipods, and sculpins (food chain members) in Lake Michigan.

Results:

Organisms have been collected at monthly intervals from a Lake Michigan site off Grand Haven, along with samples of lake water and underlying sediments. Seasonal maxima in concentrations of lipids, PCBs, and DDE occur in June or July, and lipid compositions vary over the collection period. Body burdens of contaminants generally increase with increases in trophic level and appear to bear complicated relationships to lipid contents and dietary sources.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 103

EVANS, M.S.; RICE, C.P.

Michigan - University of Michigan, Ann Arbor  
Great Lakes Research Division

## TOXAPHENE COMPARTITION AND RECYCLING IN LAKE MICHIGAN

Starting date: 1/01/1983

Completion date: 6/30/1986

Project no: R/TS-26

Sponsor: Michigan Sea Grant College Program

AREA: Lake Michigan

### KEYWORDS:

chemistry, organics, bioaccumulation, water quality, metabolism, transport, invertebrates, fish, cycling, sediment traps, zooplankton, phytoplankton, toxics, biology, chub, lake trout, sculpin, fate, toxaphene, food chain, Mysis, Amphipoda, Pontoporeia, benthic, model, organochlorine pesticides

### DESCRIPTION:

#### Objectives:

1983-84. 1) Investigate toxaphene bioaccumulation and trophic transfer through a plankton-mysid-amphipod-sculpin food web. 2) Characterize physical mechanisms for toxaphene transport. 3) Investigate temporal variability in short-lived organisms. 4) Compare toxaphene ecotoxicology with other contaminants. 5) Obtain quantitative information on toxaphene chromatographic patterns.

1985. 1) Continue #5 objective. 2) Investigate toxaphene biomagnification in bloaters and lake trout. 3) Test some of the existing mathematical models for the fate and transport of hydrophobic pollutants in pelagic food webs.

#### Methodology:

This study is based on obtaining qualitative and quantitative information on toxaphene levels in plankton, mysids, amphipods, sculpins, and sediment trap samples collected in 1982. A peak selection computer program was developed which allows the collection of this quantitative information. Principal component analysis will be used to investigate toxaphene mixtures in the various components of the ecosystem under investigation.

#### Accomplishments:

This study has confirmed that toxaphene does occur

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

in the Great Lakes ecosystem and at levels which are comparable to those observed for PCBs. Thus it has provided new data on a poorly understood contaminant in the Great Lakes ecosystem. Preliminary data has illustrated various aspects of its biomagnification and fate.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 104

EVANS, M.S.; SCHELSKE, C.

Michigan - University of Michigan, Ann Arbor  
Great Lakes Research Division

CHARACTERIZATION OF PARTICULATE FLUX IN SOUTHEASTERN  
LAKE MICHIGAN

Starting date: 1/01/1983

Completion date: 12/31/1984

Project no: R/ER-16

Sponsor: Michigan Sea Grant College Program

AREA: Southeastern Lake Michigan

KEYWORDS:

chemistry, physical, transport, sediments, cycling,  
water quality, zooplankton, nutrients, silica, flux,  
organic carbon, chlorophyll, particulates, inorganics,  
phytoplankton, pathways

DESCRIPTION:

Objectives:

To investigate particulate flux dynamics in  
southeastern Lake Michigan from 1982 samples.

This includes the characterization of particulate  
flux components (fecal pellets, mineral crystals,  
phytoplankton, etc.) and seasonality of such  
flux. Theoretical settling velocities are  
calculated to estimate major transport routes.  
Biogenic silica flux is calculated to estimate  
seasonality and major pathways.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 105

FAHNENSTIEL, G.L.; CARRICK, H., JR.  
Michigan - NOAA/GLERL, Ann Arbor

AUTOTROPHIC PICOPLANKTON AND NANNOPLANKTON STUDIES  
IN THE GREAT LAKES

Starting date: 1987  
Completion date: Continuing  
Project no: Task 5.29; Task 5.30  
Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

biology, phytoplankton, primary production,  
nutrients, phosphorus, zooplankton grazing,  
cycling, inorganics

DESCRIPTION:

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 106

FAHNENSTIEL, G.L.; SCAVIA, D.

Michigan - NOAA/GLERL, Ann Arbor

NUTRIENT-LIGHT REGULATION OF PHYTOPLANKTON GROWTH  
IN SUBSURFACE PHYTOPLANKTON POPULATIONS

Starting date:

Completion date: 1984

Project no: Task 5.16

Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

biology, phytoplankton, growth, nutrients, light,  
botany, inorganics

DESCRIPTION:

Objective:

To determine the role of nutrients and light in  
regulating phytoplankton growth of subsurface  
phytoplankton populations.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 107

FAHNENSTIEL, G.L.; SCAVIA, D.  
Michigan - NOAA/GLERL, Ann Arbor

LAKE MICHIGAN ECOSYSTEM EXPERIMENT--IN SITU  
SPECIES SPECIFIC GROWTH RATES AND SUBSURFACE  
PHYTOPLANKTON MAXIMA IN LAKE MICHIGAN

Starting date:  
Completion date: 1986  
Project no: Task 5.21  
Sponsor: NOAA

AREA: Lake Michigan

KEYWORDS:

biology, phytoplankton, growth,  
light, primary production, photosynthesis,  
heterotrophy, autotrophy, botany

DESCRIPTION:

Objectives:

- (1) To determine the magnitude and role of species-specific in situ growth in the development and maintenance of subsurface phytoplankton populations.
- (2) To determine species-specific phytosynthesis vs. light relationships for surface and subsurface phytoplankton populations and compare those results with in situ measurements of primary production.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 108

FONTAINE, T.D.; LESHT, B.M.

Michigan - NOAA/GLERL, Ann Arbor;

Illinois - Argonne National Laboratory, Argonne

Atmospheric Physics Section

A STOCHASTIC OPTIMIZATION FRAMEWORK FOR IDENTIFYING  
COST EFFECTIVE PHOSPHORUS MANAGEMENT STRATEGIES FOR  
THE GREAT LAKES

Starting date: 1985

Completion date: Continuing

Project no: Task 9.21

Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

chemistry, model, phosphorus, nutrients, inorganics,  
management, economics, abatement, water quality,  
eutrophication, pollution

DESCRIPTION:

Objectives:

- (1) To modify Chapra's (1983) steady-state phosphorus model and optimization program so that the effects of environmental variability on optimal phosphorus control strategies can be assessed.
- (2) To determine if optimal phosphorus control strategies derived from models run with average conditions will be more or less cost effective than strategies derived from models which take into account environmental variability.
- (3) To predict expected natural variability of phosphorus concentrations in the Great Lakes.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 109

FRASER, G.; THOMPSON, T.

Indiana - State Geological Survey, Bloomington

SEDIMENTOLOGY STUDIES IN LA PORTE AND ST. JOSEPH  
COUNTIES, INDIANA AND INDIANA DUNES NATIONAL LAKESHORE

Starting date:

Completion date: Continuing

Project no:

Sponsor: Indiana State Geological Survey

AREA: Indiana shoreline of Lake Michigan; Indiana Dunes  
National Lakeshore

KEYWORDS:

geology, sediments, lake levels, lake stages, glacial,  
historical, sand dunes, beach, sedimentology, dating,  
carbon-14

DESCRIPTION:

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 110

FRIDGEN, J.

Michigan - Michigan State University, East Lansing  
Parks and Recreation Dept.

## ATTITUDE, IMAGE AND PERCEPTION SHIFTS FOLLOWING GREAT LAKES VACATION TRAVEL

Starting date: 2/01/1986  
Completion date: 1/31/1988  
Project no: R/R-15  
Sponsor: Michigan Sea Grant College Program

AREA: Great Lakes; Michigan waters

### KEYWORDS:

travel, sociology, tourism, recreation, economics

### DESCRIPTION:

#### Objectives:

- 1) Compare pre-visit and post-visit perceptions of Great Lakes coastal travel destinations.
- 2) Identify barriers to potential travel in the Great Lakes coastal zone.
- 3) Estimate the conversion rate among inquirers to the state of Michigan.
- 4) Determine the strength and stability over time of perceptions toward coastal destinations.
- 5) Issue reports and recommendations on the findings and the marketing implications.

#### Methodology:

This is a two-year longitudinal study of the shifts in perceptions following visits to target destinations in the coastal zone. Travelers will be sampled via phone and mail from travel inquiries to the State of Michigan. Pre-trip and post-trip assessment of images, attitudes and perceptions will be utilized.

#### Rationale:

The Great Lakes are a unique resource and popular tourism and recreation attraction. Understanding the impacts and effects of visiting the Great Lakes coastal zone will assist the Great Lakes states and coastal communities in their efforts to diversify their economic base. Few agencies beyond Sea Grant draw cross disciplinary attention to the Great Lakes resources with research focusing upon the economic, biological, and social, tourism and recreation issues.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 111

GARDNER, W.S.

Michigan - NOAA/GLERL, Ann Arbor

SPECIATION OF DISSOLVED AND PARTICULATE PHOSPHORUS  
COMPONENTS IN TRIBUTARY AND LAKE WATER AND SEDIMENTS

Starting date:

Completion date: 1985

Project no: Task 6.29

Sponsor: NOAA

AREA: Lake Michigan; Laboratory; tributaries

KEYWORDS:

chemistry, nutrients, phosphorus, tributaries,  
sediments, water quality, inorganics

DESCRIPTION:

Objective:

To fractionate and characterize dissolved and  
particulate phosphorus forms in tributary and  
lake waters.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 112

GARDNER, W.S.; CHANDLER, J.F.; LAIRD, G.A.  
Michigan - NOAA/GLERL, Ann Arbor

PELAGIC MICRO FOOD WEB NITROGEN TRANSFORMATION  
IN LAKES MICHIGAN AND HURON

Starting date: 1987  
Completion date: Continuing  
Project no: Task 5.28  
Sponsor: NOAA

AREA: Lake Michigan; Lake Huron

KEYWORDS:

biology, bacteria, nitrogen, nutrients, inorganics,  
cycling, food chain

DESCRIPTION:

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 113

GARDNER, W.S.; CICHOCKI, E.A.; FREZ, W.A.; NALEPA, T.F.  
Michigan - NOAA/GLERL, Ann Arbor

LIPID CONTENT AND ENERGY FLOW THROUGH PONTOPOREIA HOYI  
AND OTHER BENTHIC INVERTEBRATES IN LAKES MICHIGAN AND  
ST. CLAIR

Starting date: 1984  
Completion date: 1985  
Project no: Task 6.37  
Sponsor: NOAA

AREA: Great Lakes; Southern Lake Michigan; Lake St. Clair

KEYWORDS:

biology, benthic invertebrates, Pontoporeia, Amphipoda,  
lipids, biochemistry, energy flow, food chain,  
diet, calories, bioenergetics

DESCRIPTION:

Objectives:

- (1) To develop micromethodology to extract, purify, and measure lipids in individual benthic macroinvertebrates.
- (2) To determine lipid content and seasonal trends in *P. hoyi* and other important Great Lakes macroinvertebrates.
- (3) To estimate the total and area-specific caloric content of macroinvertebrates in Southern Lake Michigan and Lake St. Clair.
- (4) To estimate the importance of *P. hoyi* in energy transfer from detrital material to small fish (and other *P. hoyi* predators) in southern Lake Michigan.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 114

GARDNER, W.S.; GAUVIN, J.M.; NALEPA, T.F.  
Michigan - NOAA/GLERL, Ann Arbor

EFFECTS OF STARVATION ON THE PHYSIOLOGY AND NUTRIENT  
CYCLING RATES OF PONTOPOREIA HOYI

Starting date: 1984  
Completion date: Continuing  
Project no: Task 6.41  
Sponsor: NOAA

AREA: Laboratory

KEYWORDS:

biology, benthic invertebrates, diet, starvation, lipids,  
physiology, nutrients, inorganics, cycling, Pontoporeia,  
Amphipoda

DESCRIPTION:

Objective:

To determine nutrient release rates and lipid content in  
P. hoyi on freshly collected animals and during various  
stages of food deprivation.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 115

GARDNER, W.S.; NALEPA, T.F.  
Michigan - NOAA/GLERL, Ann Arbor

NUTRIENT MINERALIZATION IN AEROBIC LAKE SEDIMENTS:  
BENTHIC INVERTEBRATE-MICROBIAL INTERACTIONS

Starting date: 1982  
Completion date: 1986  
Project no: Task 6.33  
Sponsor: NOAA

AREA: Lake Michigan

KEYWORDS:

biology, chemistry, nutrients, mineralization,  
aerobic, sediments, oxygen, benthic, invertebrates,  
bacteria, nitrogen, inorganics

DESCRIPTION:

Objectives:

To determine nitrogen mineralization rates and  
the relative importance (and interactions) of  
benthic invertebrates and microbes to the  
mineralization process in aerobic lake sediments.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 116

GARDNER, W.S.; NALEPA, T.F.; QUIGLEY, M.A.  
Michigan - NOAA/GLERL, Ann Arbor

TRANSFER OF ENERGY FROM PELAGIC PHYTOPLANKTON TO  
PONTOPOREIA HOYI IN LAKE MICHIGAN

Starting date: 1/1986  
Completion date: 6/1988  
Project no: Task 6.44  
Sponsor: NOAA

AREA: Lake Michigan off Grand Haven, Michigan; Laboratory

KEYWORDS:

biology, food chain, phytoplankton, bacteria,  
benthic invertebrates, Pontoporeia, Amphipoda,  
energy flow, calories, detritus, nutrition,  
populations, biomass, growth, diet,  
lipids, sediments

DESCRIPTION:

Objectives:

- (1) To examine mechanisms of energy transport from the pelagic food web to *P. hoyi*, the dominant benthic macroinvertebrate in the upper Great Lakes,
- (2) To measure caloric content and lipid composition in seasonal detrital food supplies (sediment trap material and surface sediments) potentially available to *P. hoyi* in Lake Michigan.
- (3) To determine the proportion of assimilated energy in *P. hoyi* that is derived from bacteria, living algae, and detritus.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 117

GARLING, D.; TANNER, H.

Michigan - Michigan State University, East Lansing  
Dept. of Fisheries and Wildlife

PRODUCTION OF TRIPLOID AND HYBRID COHO AND CHINOOK  
SALMON

Starting date: 1983

Completion date: 1986

Project no:

Sponsor: Michigan Sea Grant College Program; Michigan  
Agricultural Exp. Station; American Tackle  
Manufacturers Association; Lowrance; and various  
sportsangler groups

AREA: Laboratory; Great Lakes

KEYWORDS:

fish, biology, growth, coho salmon, chinook salmon,  
genetics, salmonid, sterilization

DESCRIPTION:

Objectives:

- 1) To examine the feasibility of producing triploid chinook and coho salmon for stocking in the Great Lakes.
- 2) To observe differences in the growth and survival of triploid and normal salmon held at Wolf Lake Fish Hatchery, Michigan Dept. of Natural Resources, and Michigan State University Aquaculture Laboratory.
- 3) To observe differences in growth, condition, and distribution of microtagged triploid salmon released in the Great Lakes.

Rationale:

Great Lakes chinook salmon mature at an age of about 4 years, return to streams to spawn, and die within 2-3 weeks of spawning. Triploid chinook salmon will be sterile and should live longer, grow larger, and not go through the degenerative processes associated with spawning. Triploids could provide a new trophy salmon fishery for the Great Lakes without the introduction of a new species.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 118

GEFFEN, A.; NASH, R.

Maine - Unity College, Unity  
Environmental Sciences Center

PROLONGED RECRUITMENT OF YOUNG-OF-THE-YEAR RAINBOW SMELT TO  
BOTTOM TRAWLS: MIGRATION OR CESSATION OF GROWTH

Starting date: 6/01/1983

Completion date: 8/30/1985

Project no: R/LR-24, part of

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Eastern Lake Michigan; off Grand Haven; Michigan waters

KEYWORDS:

biology, fish, populations, otoliths, distribution,  
populations, growth, larval fish, movement,  
recruitment, rainbow smelt, predation, diet

DESCRIPTION:

This project was part of Project No. R/LR-24 of  
Magnuson and Crowder, UW-Madison.

Objectives:

- (1) To examine the diet overlap of rainbow smelt with that of alewife and yellow perch;
- (2) To examine the offshore distribution of rainbow smelt off Grand Haven, Michigan;
- (3) To study predation rates on rainbow smelt.

Methodology:

Field sampling to determine the mechanisms of recruitment and the factors affecting year class strength and the competition for food for rainbow smelt.

Results:

Rainbow smelt in the size range 30-55 mm were present in all samples encompassing a 12-month period. Fish were sampled with bottom trawls from depths 5 to 75 m in eastern Lake Michigan. Migration into the sampling area was evident during the summer months (July-Sept. 1983) using length-frequency and otolith ring counts. Between Nov. 1983 and April 1984, however, neither length-frequency distributions nor primary increment counts showed any change in the population sampled. This may be explained by cessation of growth and increment deposition by those smelt which overwinter in the larval stage. The advantages of this growth strategy are not immediately apparent as predation pressure would be heavy on this size group.



# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 119

GERNANT, R.E.; BURKE, C.D.

Wisconsin - University of Wisconsin-Milwaukee  
Geological and Geophysical Sciences Dept.;  
Kansas - Wichita State University, Wichita  
Geology Dept.

## PALEOECOLOGY OF LAKE MICHIGAN OSTRACODA

Starting date: 1983

Completion date: 1986

Project no:

Sponsor: University of Wisconsin, Milwaukee

AREA: Lake Michigan; Green Bay

### KEYWORDS:

geology, fossils, biology, distribution, ostracods,  
sediment cores, sediments, historical, stratigraphy,  
lake stages, paleoecology, paleolimnology,  
populations, lake levels

### DESCRIPTION:

#### Objectives:

(1) To examine the paleoecology and biostratigraphy of Lake Michigan Ostracoda; (2) To utilize Fourier analysis of the shape of both living and fossil Ostracoda.

#### Results:

Lake Michigan living and fossil Ostracoda can be subdivided into two assemblages. The deep-water candonid community that characterizes Quaternary sediments from high-water stages of the Lake. The shallow-water community consists of highly diverse evenly distributed ostracods. This assemblage occurs in shallower, warmer water and dominates ancient sediments deposited during periods of lowered lake level. Fossil ostracod trends in the various subunits of the Quaternary Lake Michigan Formation can be associated with major oscillations of lake surface elevation. All but one historic lake stage are characterized by unique ostracod assemblages and sediments.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 120

GIESY, J.

Michigan - Michigan State University, East Lansing  
Pesticide Research Center

## PHOTOTOXICITY OF POLYCYCLIC AROMATIC HYDROCARBONS TO LAKE MICHIGAN PLANKTON

Starting date: 2/01/1985

Completion date: 1/31/1987

Project no: R/TS-28

Sponsor: Michigan Sea Grant College Program

AREA: Lake Michigan

### KEYWORDS:

phototoxicity, toxics, biology, chemistry, phytoplankton, zooplankton, PAHs, organics, UV irradiance, water quality, synergism, additivity, light, Cladocera, green algae

### DESCRIPTION:

#### Objectives:

- 1) Determine if phototoxicity is a property of PAH other than anthracene, which have absorbance maxima in the UV and UVB ranges of solar irradiance.
- 2) Determine the active waveband of irradiance (UVA, UVB, visible) required to elicit phototoxicity of different PAH to phytoplankton and zooplankton.
- 3) Determine the threshold quantity of light required for toxicity of PAH to *Daphnia magna* and *Selenastrum capricornutum*.
- 4) Conduct field experiments to test predictions from experiments made under laboratory conditions for *D. magna*, *S. capricornutum* and mixed populations of phytoplankton and zooplankton in Lake Michigan.
- 5) Test for additivity and synergisms among PAH under different irradiance conditions.

#### Methodology:

Laboratory and field incubations of cultures and natural assemblages to determine effects of PAH on phytoplankton and zooplankton in Lake Michigan or UV irradiance relevant to Lake Michigan.

#### Rationale:

While a number of studies have been conducted by Sea Grant and other agencies into the concentrations of and dynamics of distribution of trace contaminants, few studies have been conducted to determine the effects of these residues on the biota of the Great Lakes. This study will mesh with the efforts of GLERL/NOAA into the dynamics of PAH. Furthermore, this study will address a call from the IJC Nonpoint Task

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Force into nonpoint source contaminants, which PAH are.  
Benefits:

This information will make it possible to assess the potential for adverse effects due to the great loadings of photosensitizing compounds to Lake Michigan. Our preliminary studies indicate that under field conditions PAH are more than 1000 times more toxic than would be predicted from laboratory studies.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 121

GIESY, J.

Michigan - Michigan State University, East Lansing  
Pesticide Research Center

AMINO ACID ALTERATION AS A MEASURE OF STRESS IN  
GREAT LAKES BENTHOS

Starting date:

Completion date: 1986

Project no:

Sponsor: NOAA/GLERL

AREA: Southern Lake Michigan; Laboratory; Great Lakes

KEYWORDS:

amino acids, biochemistry, biology, toxics, stress,  
organics, Amphipoda, oligochaetes, analytical methods,  
contaminants, growth, reproduction, chlorophenols,  
benthic invertebrates, bioassay, physiology

DESCRIPTION:

Objective:

To develop a sensitive chronic stress test for  
freshwater invertebrates and to employ it on  
benthic organisms of the Great Lakes.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 122

GIESY, J.; ZABIK, M.J.

Michigan - Michigan State University, East Lansing  
Pesticide Research Center

## EFFECTS OF MATERNAL EXPOSURE OF RAINBOW TROUT TO 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN (TCDD) ON REPRODUCTION

Starting date: 7/01/1987

Completion date: 6/30/1990

Project no: R/TS-31

Sponsor: Michigan Sea Grant College Program

AREA: Lake Michigan; Lake Huron; Lake Superior; Laboratory

### KEYWORDS:

chemistry, organics, TCDD, dioxins, PCDD, PCDF, TCDF, dibenzo-p-dioxins, dibenzofurans, furans, contaminants, rainbow trout, salmonid, mortality, toxics, reproduction, chinook salmon, lake trout, steelhead, biology, bioassay, fish, eggs, analytical methods, pattern recognition

### DESCRIPTION:

#### Objectives:

1. Determine the dose-lethality relationship for eggs and fry from adult female rainbow trout exposed to ecologically relevant waterborne concentrations of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD).
2. This information, in conjunction with the concentration of 2,3,7,8-TCDD in eggs of salmonid fishes from the Great Lakes, will be used in a hazard assessment to determine the hazard presently existing and potential future concentrations of 2,3,7,8-TCDD.
3. For 3 species of fish (chinook, lake trout, and steelhead) in Lakes Huron, Michigan, and Superior: Determine the isomer group ratios for PCDD's (C14-C18); PCDF's (C14-C18); TCDD's and TCDF's in fish and fish eggs.
4. Examine the use of isomer group ratios: to identify sources and background concentrations and employ pattern recognition to the distribution, source, and background concentrations of dioxins and furans in Great Lakes fish eggs.

#### Methodology:

Eggs and tissues from salmonids from Lakes Huron, Michigan, and Superior will be collected by MDNR, U.S.F.W.S., and the Commercial Fisheries. Reversed phase HPLC on Zorbax ODS with methanol eluent will separate chemically similar species from PCDF's and separates CDD's by degree of chlorination. Isomers in the HPLC fractions

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

will be measured by GC/MS and interpreted using pattern recognition techniques. Adult, 200 g, rainbow trout will be exposed to waterborne concentrations of  $5.0 \times 10^{-3}$ ,  $5.0 \times 10^{-2}$  and 0.1 mg  $^3\text{H}$ -labelled 2,3,7,8-TCDD per liter for one year. Concentrations of TCDD in tissues of the adult fish as well as the eggs and fry and mortality will be determined.

### Rationale:

Polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) result from many human activities and are widespread in the environment. These compounds can be extremely toxic to fish. Dose-response relationships are needed to be able to assess the hazard of these compounds to fish eggs and fry, where they tend to be concentrated. This study will mesh with the efforts of GLERL/NOAA into the dynamics of PAH. Furthermore, this study will address a call from IJC Nonpoint Task Force to initiate more studies into nonpoint source contaminants, such as dioxins and dibenzofurans.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 123

GLASS, G.; SORENSON, J.

Minnesota - U.S. EPA Environmental Research Lab, Duluth

VARIATIONS IN CONDITIONS AFFECTING POLLUTANT REACTIVITY IN  
OPEN WATERS OF THE GREAT LAKES: IMPLICATION FOR SUSCEPTIBILITY

Starting date: 1985

Completion date: 1986

Project no:

Sponsor: U.S. EPA - Duluth

AREA: Great Lakes

KEYWORDS:

chemistry, fate, pathways, toxics, organics, pollutants,  
model, water quality, contaminants, behavior

DESCRIPTION:

Nuisance growths, fishery loss and trophic state presently define pollution control measures for the Great Lakes but evidence of toxic impacts from persistent substances is increasing. Eleven of the priority pollutants identified by the IJC are of this type and have substantial inputs from diffuse and airborne sources. Control of these polluting substances will require specific information defining source regions, processes and mechanisms controlling their deposition and dispersion, and in-lake impacts. Differences in impacts may exist for Great Lakes' waters due to differences in inputs, hydrology, trophic status and pollutant reactivity. This project has examined the properties of the open waters to define the conditions controlling the reactivity of persistent substances. Measurements of physical and chemical properties show important differences in reactivity conditions such as temperature, viscosity, ionic strength and mobility, ion concentration and related factors. The general basis for pollutant reactivity indicates potential for significant differences in impact susceptibility across the Great Lakes.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 124

GORDEN, R.; HORNS, W.

Illinois - Illinois Natural History Survey, Champaign

SPORTFISHING CREEL CENSUS OF THE ILLINOIS PORTION  
OF LAKE MICHIGAN

Starting date: 2/01/1985

Completion date: 4/30/1989

Project no:

Sponsor: Illinois Dept. of Conservation

AREA: Illinois waters of Lake Michigan

KEYWORDS:

recreation, biology, creel census, sport fishing,  
fish, management, salmonid, lake trout, coho salmon,  
chinook salmon, rainbow trout, brown trout, yellow perch

DESCRIPTION:

The creel survey covers all sport fishing in the Illinois waters of Lake Michigan, with the exception of charter-boat fishing. The following components of the sport fishery are covered: summer fishing (including pedestrian angling, fishing from launched boats kept at moorings), smelt fishing, snagging, and winter fishing (including ice fishing and fishing in power plant discharge areas). The general intent of the project is to provide reliable estimates of sport fishing activity, sport fish harvest, expenditures for sport fishing, and the quality of sport fishing.

The first year of the continuing creel survey ended 1 April 1986. It was estimated that 1.3 million yellow perch, 120,000 coho salmon, and over 50,000 chinook salmon were caught by Illinois anglers (excluding charter boat fishing).

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 125

GORDEN, R.; HORNS, W.

Illinois - Illinois Natural History Survey, Champaign

YELLOW PERCH GROWTH IN SOUTHERN LAKE MICHIGAN

Starting date: 7/01/1986

Completion date: 6/30/1988

Project no:

Sponsor: Illinois Dept. of Conservation

AREA: Illinois waters of Lake Michigan

KEYWORDS:

biology, yellow perch, fish, growth, populations,  
distribution, abundance, size

DESCRIPTION:

This research attempts to determine whether the yellow perch growth rate is reduced when the species is abundant. Yellow perch abundance has fluctuated widely over the past 30 years. Today this species is abundant, sustaining both sport and commercial fishing in Illinois and neighboring states. The U.S.F.W.S. reported that there has been an apparent decline in growth associated with the increase in numbers. If growth is strongly influenced by abundance, then management restrictions on sport and commercial harvests can influence the size of fish available to anglers and commercial fishermen.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 126

GRANT-NORPAC, INC.

Texas - Grant-Norpac, Inc., Houston

REGIONAL GEOPHYSICAL SURVEYS OF THE GREAT LAKES

Starting date: 1984

Completion date: 1985

Project no:

Sponsor: Grant-Norpac, Inc.

AREA: Lake Michigan; Lake Superior; Lake Huron; Lake Ontario;  
Lake Erie

KEYWORDS:

geology, geophysical, mapping, satellite,  
magnetic data

DESCRIPTION:

Regional geophysical surveys were conducted on the Great Lakes using satellite data and Loran-C navigation. Gravity data were acquired utilizing an air/sea Lacoste and Romberg gravity meter. A geometric magnetometer with tow cable and sensor was utilized to acquire all magnetic data. Over 2280 miles of data available.

Ref. no. 127

GREEN, A.; BEHRENDT, J.

Ontario - Geol. Surv. Canada, Ottawa

Colorado - U.S. Geological Survey, Denver

DEEP SEISMIC SURVEY IN THE GREAT LAKES

Starting date: 1986

Completion date: Continuing

Project no:

Sponsor: Geol. Surv. Canada; U.S. Geological Survey

AREA: Lake Michigan; Lake Superior; Lake Huron

KEYWORDS:

geology, geophysical, seismic surveys, mapping

DESCRIPTION:

The Great Lakes International Multidisciplinary Program on Crustal Evolution (GLIMPCE) is primarily concerned with resolving the crustal structure of the mid-continent. In September 1986, through commercial contract, GLIMPCE collected 1350 km of deep seismic reflection data from Lakes Huron, Michigan, and Superior. Complementary seismic refraction data were recorded by five lake bottom seismographs and by more than thirty land-based stations. The GLIMPCE survey will be available to interested users in 1987.

Ref. no. - 128

GREENE, G.M.; CLITES, A.H.; CAMPBELL, J.E.;  
BENNETT, J.R.

Michigan - NOAA/GLERL, Ann Arbor

# VERIFICATION OF ICE TRANSPORT MODEL

Starting date:

Completion date: 1985

Project no: Task 8.14

Sponsor: NOAA

AREA: Great Lakes; Lake Erie

## KEYWORDS:

model, ice, physical, transport,  
motion, thickness

## DESCRIPTION:

### Objectives:

- 1) To measure ice cover motion and thickness for use in calibrating and verifying the Great Lakes ice dynamics simulation model.
- 2) To provide descriptive information on ice transport and transport processes in the central and eastern basins of Lake Erie

Ref. no. 129

HANSEL, A.; MICKELSON, D.; SCHNEIDER, A.; LARSEN, C.  
Illinois - Illinois State Geological Survey, Champaign;  
Wisconsin - University of Wisconsin-Madison, Madison  
Geology and Geophysics Dept.;  
Wisconsin - University of Wisconsin-Parkside, Kenosha;  
Virginia - U.S. Geological Survey, Reston

LATE WISCONSINAN AND HOLOCENE HISTORY OF THE  
LAKE MICHIGAN BASIN

Starting date: 1982  
Completion date: Continuing  
Project no:  
Sponsor: Illinois State Geological Survey; University of  
Wisconsin-Madison; University of Wisconsin-Parkside

AREA: Lake Michigan

KEYWORDS:

geology, historical, lake levels, glacial, lake stages,  
carbon-14, dating

DESCRIPTION:

This project is examining the lake chronology in the Lake Michigan basin. Mechanisms of lake level changes, relationships of glacial and lake events, and the effect of differential isostatic rebound on the lake history are being studied.

Ref. no. 130

HARRIS, H.J.; KUBIAK, T.J.; TRICK, J.A.

Wisconsin - University of Wisconsin, Green Bay  
Sea Grant Institute;

Wisconsin - U.S. Fish and Wildlife Service, Green Bay;

Wisconsin - University of Wisconsin, Green Bay  
Sea Grant Institute

THE ROLE OF MICROCONTAMINANTS IN THE REPRODUCTIVE  
FAILURE OF FORSTER'S TERNS ON GREEN BAY

Starting date: 1983

Completion date: 1985

Project no: R/GB-21

Sponsor: University of Wisconsin Sea Grant Institute; U.S.  
Fish and Wildlife Service; Green Bay Metropolitan  
Sewerage District

AREA: Green Bay; Lake Michigan; Lake Poygan

KEYWORDS:

birds, biology, physiology, organics, PCBs, PCDD, PCDF,  
TCDD, dioxins, furans, toxics, contaminants, eggs, terns,  
reproduction

DESCRIPTION:

Objectives:

To determine if reproductive success of the Forster's terns on lower Green Bay was different from an inland colony on Lake Poygan. If differences were observed, could they be associated with known effects of chemical toxicants, i.e., PCBs, PCDD, PCDF.

Results:

1. There was a clear impairment of the reproductive capacity of Forster's terns nesting on Green Bay in 1983.
2. There was no indication of virological disease in eggs from either Green Bay or Lake Poygan.
3. The biological parameters tested appear consistent with known effects of 2,3,7,8-TCDD, its isoteres and/or PCBs generally.
4. Evidence from artificial incubation experiments leads one to conclude that impaired reproduction of the Forster's terns on Green Bay is due in part to embryotoxic (intrinsic) effects.
5. Extrinsic factors related to parental attentiveness are also responsible for reproductive impairment of the Forster's tern on Green Bay.
6. There were significantly higher concentrations of 2,3,7,8-TCDD, HCDD, total PCDDs, total non-ortho, ortho' PCBs and total PCBs in Forster's tern eggs from Green Bay



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

than from Lake Poygan.

7. Dioxins, PCBs and other cytochrome P448-active compounds which have not been characterized, should not be discounted as causative factors in the reproductive impairment of nesting Forster's terns on Green Bay.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 131

HARRIS, H.J.; MCLAUGHLIN, D.B.

Wisconsin - University of Wisconsin, Green Bay  
Sea Grant Institute

AQUATIC INSECT EMERGENCE PATTERN IN TWO GREAT LAKES  
COASTAL MARSHES

Starting date:

Completion date: 1985

Project no:

Sponsor: Sponsor Not Known

AREA: Green Bay; Lake Michigan

KEYWORDS:

biology, wetlands, abundance, composition, biomass,  
macrophytes, food chain, populations, invertebrates,  
damselflies, botany, vegetation, insects

DESCRIPTION:

This study examines trends in the emergence of aquatic insects in two Green Bay marshes. The abundance, composition, and biomass of insects emerging from a diked and undiked marsh in summer, 1984 was assessed. Four cover types were sampled: open water, sparse and dense persistent emergents, and wet meadow. Preliminary analysis shows that total insect abundance was nearly 60% greater in the diked marsh. Total biomass was at least 100% greater. Of the four cover types, sparse emergents produced the greatest number of insects. Greatest biomass occurred in sparse and dense emergent cover in both marshes. Damselflies (Coenagrionidae) had the greatest influence on biomass and were abundant in the diked marsh but very rare in the undiked marsh. This study shows that the nature of wetland food chains can vary considerably, not only among marshes, but also among marsh cover types.

Ref. no. 132

HARRIS, H.J.; RICHMAN, S.; SAGER, P.

Wisconsin - University of Wisconsin, Green Bay  
Sea Grant Institute;

Wisconsin - Lawrence University, Appleton  
Biology Dept.;

Wisconsin - University of Wisconsin, Green Bay  
Dept. of Science and Environmental Change

CONTRIBUTION OF MARSHLANDS TO THE GREEN BAY PELAGIC  
FOOD CHAIN

Starting date: 9/01/1982

Completion date: 8/31/1985

Project no: R/GB-18

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Green Bay; Lake Michigan

KEYWORDS:

wetlands, organic carbon, food chain, zooplankton, botany,  
nutrients, phytoplankton, primary production, inorganics,  
biology, chemistry, seiche, detritus, nitrogen, cycling,  
phosphorus, particulates, transport, zooplankton grazing

DESCRIPTION:

Objectives:

To determine what portion of the primary  
production of the Green Bay coastal marshes  
is exported to the off-shore waters, as well  
as the form (dissolved or particulate carbon)  
in which it is transported and the temporal  
pattern of the export; if the exported, parti-  
culate detritus from the marshes is a suitable  
food source for the major zooplankton species  
of the bay; and what the nature of the nutrient  
(P and N) flux between the marshes and the off-  
shore waters consists of.

Methodology:

Use automatic sampler during seiche periods  
measured with water level recorder; analyze  
N and P compounds on auto-analyzer; use  
carbon analyzer; perform zooplankton  
feeding experiments with Coulter Counter  
interfaced to microcomputer.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 133

HARTMAN, W.

Michigan - National Fisheries Center - Great Lakes, Ann Arbor

PERFORMANCE OF THREE STRAINS OF LAKE TROUT STOCKED  
IN A REFUGE--LAKE MICHIGAN

Starting date: 10/1985

Completion date: 9/1990

Project no:

Sponsor: U.S. Fish and Wildlife Service

AREA: Northern Lake Michigan

KEYWORDS:

biology, lake trout, fish, rehabilitation, spawning,  
reefs, habitat, refuge, management, stocking, fish strains,  
populations, dispersal, growth, survival, temperature,  
diet, salmonid, mortality, reproduction

DESCRIPTION:

To ascertain whether a refuge might permit the buildup of a large spawning stock of lake trout, and to determine which of several strains might perform best in Lake Michigan, the Lake Michigan Committee (GLFC) has established a large refuge in the northern part of the lake that will be stocked intensively in spring 1986 with yearling lake trout of three strains. Systematic sampling each year with trawls and gillnets is necessary to collect data on dispersal, growth, survival, depth, and temperature preference, and diet for each strain.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 134

HATCH, R.W.; BROWN, E.

Michigan - National Fisheries Center - Great Lakes, Ann Arbor

SIZE, PRODUCTIVITY, AND HARVESTABLE SURPLUS OF  
GREAT LAKES FISH STOCKS

Starting date: 1979

Completion date: Continuing

Project no:

Sponsor: U.S. Fish and Wildlife Service

AREA: Lake Michigan; Lake Superior; Lake Huron

KEYWORDS:

fish, biology, lake trout, chub, whitefish,  
populations, management, biomass, salmonid,  
commercial fishing

DESCRIPTION:

This work unit provides sophisticated technical assistance in data analysis and population dynamics to and in collaboration with state and provincial DNRs, tribes, etc., for estimating the productivity of selected fish resources and their potential harvestable surplus. Since 1979, and continuing into the foreseeable future, the primary responsibility has been the lead role in working with MDNR and the tribes in annually collecting, collating, and analyzing data on major stocks of lake trout, chubs, and whitefish in Treaty-ceded waters of the upper Great Lakes, State of Michigan. This results in annual estimates of population sizes, determination of the status of the stocks, and produces recommendations for harvestable surpluses for the upcoming year.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 135

HATCH, R.W.; ECK, G.; BROWN, E.

Michigan - National Fisheries Center - Great Lakes, Ann Arbor

MAXIMUM SUSTAINABLE PREDATION ON PREY-FISH  
STOCKS (GREAT LAKES)

Starting date: 1983

Completion date: 1990

Project no:

Sponsor: U.S. Fish and Wildlife Service

AREA: Lake Michigan; Lake Huron; Lake Ontario

KEYWORDS:

model, fish, biology, salmonid, lake trout,  
salmon, predation, forage fish, populations,  
alewife, smelt, sculpin, diet, management

DESCRIPTION:

Comprehensive analytical information on total allowable predation in the Great Lakes would be of great value to management agencies, particularly to those having jurisdiction over Lakes Michigan, Huron, and Ontario, where large salmonid populations are being maintained almost entirely by hatchery stocking. The purpose of this work unit is to use simulation models as well as conventional fishing models, where predation is considered analogous to fishing, to project the effects of changing levels of salmonid predation (1) on Lake Michigan alewife populations, (2) on the composite forage population of alewives, smelt, and sculpins in Lake Michigan, and (3) on composite forage populations in Lakes Huron and Michigan.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 136

HAWLEY, N.

Michigan - NOAA/GLERL, Ann Arbor

STATISTICAL TECHNIQUES FOR THE ANALYSIS OF SUSPENDED PARTICLES

Starting date:

Completion date: Continuing

Project no: Task 3.12

Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

physical, particle size, particulates,  
suspended sediment, water quality

DESCRIPTION:

Objectives:

- (1) Develop statistical techniques which permit the quantitative characterization of suspended particle populations based on:
  - a. Particle-size distribution
  - b. Particle composition as a function of size.
- (2) Use these techniques to quantify differences in suspended populations.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 137

HAWLEY, N.; EADIE, B.J.; ROBBINS, J.A.  
Michigan - NOAA/GLERL, Ann Arbor

INVESTIGATION OF BENTHIC BOUNDARY LAYER SAMPLING  
TECHNIQUES

Starting date:  
Completion date: 6/1985  
Project no: Task 3.13  
Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

physical, benthic boundary layer, sampling,  
sediments, water quality, chemistry

DESCRIPTION:

Objectives:

- (1) To test existing equipment which sample in the bottom boundary layer.
- (2) To use the data obtained to provide guidelines for the design of new instruments.
- (3) To develop a coherent plan for future work in the bottom boundary layer.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 138

HAWLEY, N.; ROBBINS, J.A.; BELL, G.L.; EADIE, B.J.  
Michigan - NOAA/GLERL, Ann Arbor

SEASONAL VARIATIONS IN THE VERTICAL DISTRIBUTION AND  
TRANSPORT OF SHORT-LIVED RADIONUCLIDES

Starting date:  
Completion date: Continuing  
Project no: Task 3.11  
Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

model, transport, physical, chemistry, particulates,  
radionuclides, flux, sediments, seasonal, water quality,  
lead-210, cesium, polonium, beryllium

DESCRIPTION:

Objectives:

- (1) To determine seasonal variations in the vertical distribution of particulate and dissolved short-lived (beryllium-7, polonium-210), as well as long-lived (lead-210, cesium-137) radionuclides in the open lake.
- (2) To determine seasonal variations in the vertical distributions of the flux of these radionuclides.
- (3) To determine seasonal variations in the distribution and storage of these radionuclides in sediment underlying the sampling site.
- (4) To provide an experimental basis for development of whole lake and vertical transport models (Task 3.7).

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 139

HEBERLEIN, T.A.

Wisconsin - University of Wisconsin-Madison  
Rural Sociology

RECREATIONAL BOATING AND RURAL DEVELOPMENT:  
A COMPARATIVE ASSESSMENT OF BOATERS ACROSS  
TIME (1975-85) AND LOCATION (BAYFIELD AND  
DOOR COUNTIES)

Starting date: 9/01/1984

Completion date: 8/31/1987

Project no: R/PS-34

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Wisconsin waters; Bayfield County; Door County; Green  
Bay; Lake Michigan; Lake Superior

## KEYWORDS:

sociology, marketing, economics,  
marinas, leisure studies, recreation,  
boating, survey

## DESCRIPTION:

### Objectives:

To (1) describe how 1975 Bayfield-area recreational boaters have changed their boating activity over the last decade and what factors influenced these changes; (2) compare 1985 and 1975 Bayfield-area boaters to determine how use of the area has changed and what the needs and preferences of the 1985 boater are; (3) compare boater populations in Bayfield and Door Counties in terms of recreation experiences sought, economic impact, recruitment into boating and to the area; (4) use these data for specific policy analysis for the National Park Service, State of Wisconsin, charter boat operations and marina operations.

### Methodology:

Mailed 1,500 questionnaires to three visitor samples: 1975 Bayfield area boaters (500); 1985 Bayfield area boaters (500), and 1985 Door Peninsula area boaters (500). Anticipated response rate: more than 80%. Samples derived past surveys and on site sampling.

### Accomplishments:

Field sampled 1,217 Lake Superior boaters and 973 Door County boaters; 74% of the 1975 boaters located. Two questionnaires constructed, pretested and mailed to 800 respondents.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 140

HEBERT, P.D.N.; BILLINGTON, N.  
Ontario - University of Windsor, Windsor  
Great Lakes Institute  
Dept. of Biological Sciences

DISCRIMINATION OF FISH STOCKS USING MITOCHONDRIAL DNA

Starting date: 11/1986  
Completion date: 10/1989  
Project no:  
Sponsor: Natural Sciences and Engineering Research Council

AREA: Lake Michigan; Lake Ontario; Lake Huron; Lake Erie; Lake  
Superior; Canadian inland lakes; U.S. inland lakes;  
Laboratory

KEYWORDS:  
biology, fish, lake trout, salmonid, genetics, DNA, walleye

DESCRIPTION:  
Cloned mtDNA will be used to probe mtDNA in total DNA  
live fish. Mitochondrial DNA markers will be bred into  
hatchery fish and these fish used in introduction  
experiments. The final goal will be to engineer specific  
genetic markers and introduce them into the mtDNA molecule  
of fish, enabling ownership to be established, when these  
fish are released into the wild.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 141

HESS, R.

Illinois - Illinois Dept. of Conservation, Chicago  
Lake Michigan Program

FISHERIES SURVEYS AND STUDIES ON LAKE MICHIGAN

Starting date:

Completion date: Continuing

Project no:

Sponsor: Illinois Dept. of Conservation

AREA: Southern Lake Michigan; Illinois waters

KEYWORDS:

biology, fish, chub, lake trout, salmonid, mortality,  
gill netting, yellow perch, monitoring, rainbow trout,  
sport fishing, commercial fishing, creel census

DESCRIPTION:

The Lake Michigan Program includes an annual array of lake surveys: bloater chub, yellow perch, lake trout, salmonids. In addition, a sport fishing creel census is conducted with the INHS (see Gorden, R.; Horns, W.). Also, studies are being conducted with experimental gill nets in an effort to reduce catch and mortality of trout and salmon caught in such nets which are set for yellow perch and bloater chubs; also monitoring the catches of floy-tagged rainbow trout which were released in summer; also monitoring the charter boat and commercial catches from Illinois waters.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 142

HESS, R.; VIDAL, P.; TRUDEAU, T.

Illinois - Illinois Dept. of Conservation, Chicago  
Lake Michigan Program

LAKE TROUT INVESTIGATIONS

Starting date: 7/01/1984

Completion date: Continuing

Project no:

Sponsor: Illinois Dept. of Conservation

AREA: Southern Lake Michigan; Illinois waters; Waukegan;  
Julian's Reef

KEYWORDS:

biology, fish, lake trout, monitoring, spawning, reproduction,  
reefs

DESCRIPTION:

Lake Superior and Lake Seneca strains (marked fish)  
are released annually at Julian's Reef. Annual monitoring  
of stock status off Waukegan and spawning status at  
Julian's Reef.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 143

HESSELBERG, R.; HICKEY, J.

Michigan - National Fisheries Center - Great Lakes, Ann Arbor

SURVEILLANCE OF CONTAMINANTS IN GREAT LAKES FISHES

Starting date: 1977

Completion date: Continuing

Project no:

Sponsor: U.S. Fish and Wildlife Service; International Joint Commission; U.S. EPA - Great Lakes National Program Office

AREA: Lake Michigan; Lake Superior; Lake Huron; Lake Erie; Lake Ontario

KEYWORDS:

contaminants, toxics, fish, biology, water quality, organics, DDT, PCBs, dieldrin, toxaphene, chlordane, lake trout, walleye, monitoring, chemistry, organochlorine pesticides, inorganics

DESCRIPTION:

This work covers monitoring and research activities performed under cooperative agreement with U.S. EPA in fulfillment of the U.S./Canadian "International Great Lakes Fish-Contaminant Surveillance Program" as coordinated by the IJC Surveillance Subcommittee. Also included are cooperative efforts with the U.S.F.W.S. National Contaminant Biomonitoring Program. The U.S. portion of the International Program consists of the GLFL annually collecting samples of 2 species of fish from each of 6 locations in the Great Lakes and Lake St. Clair, with analysis of major contaminants in 120 composite samples by the U.S. EPA (trend monitoring). The GLFL further performs quality assurance analysis and analyzes composite samples of the largest predatory fish collected for other detectable organic and inorganic contaminants (new contaminant identification).



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 144

HOKANSON, K.; LIEN, G.J.

Minnesota - U.S. EPA Research Laboratory, Duluth

EFFECTS OF ORGANIC CONTAMINANTS IN OVA  
UPON GROWTH AND SURVIVAL OF LARVAL WALLEYE  
FROM THE LOWER FOX RIVER AND STURGEON BAY AREA OF  
GREEN BAY, WISCONSIN

Starting date: 4/1983  
Completion date: 12/1986  
Project no:  
Sponsor: U.S. EPA

AREA: Green Bay; Fox River; Sturgeon Bay; Lake Michigan

KEYWORDS:

biology, fish, walleye, reproduction, eggs, organics,  
larval fish, chemistry, toxics, mortality, water quality,  
survival, growth, contaminants

DESCRIPTION:

Estimates of growth and mortality of walleye larvae were made using ova obtained from parent fish collected at contaminated sites (i.e., lower Fox River and Sturgeon Bay, Wisconsin) and uncontaminated (i.e. Chippewa Flowage, Wisconsin). Walleye embryos and larvae from each source were reared in Lake Superior water under similar thermal regimens. Measurements were made on their growth and survival the first 3 weeks after hatching. Several lines of biological evidence suggest that contaminants are affecting reproduction of the Green Bay stock of walleye. Mortality of larvae was highest in the post-larvae I phase of development when the larvae begin to feed and have resorbed the yolk sac. A negative correlation between larval survival and female weight from all sources combined ( $r = 0.847$ ) also suggests a contaminant problem. Additionally, lower survival of walleye larvae (i.e. post-larvae I) from contaminated sites compared to control stock provided evidence of a contaminant problem. Fish from the lower Fox River (i.e. 72.6%) and Sturgeon Bay (i.e. 58.6%) had lower survival than the controls (i.e. 90.4%) in the post-larvae I phase of development. In this sensitive phase of development, Sturgeon Bay fish (i.e. 24.01%/day) grew slightly faster than those from the lower Fox River (20.70%/day) or the control site (20.72%/day). Overall larval survival varied from 35-87% and survival of larvae from smaller females was good at all sites which suggests that contaminants alone are not responsible for total recruitment failure. Observed biological effects will be correlated to organochlorine compounds in fish and ova samples.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 145

HOLM, N.P.

Illinois - Illinois State Geological Survey, Champaign  
Stratigraphy and Surficial Geology Section

LAKE MICHIGAN RESEARCH INFORMATION DATABASE

Starting date: 11/01/1986  
Completion date: 10/31/1987  
Project no:  
Sponsor: The Joyce Foundation

AREA: Lake Michigan

KEYWORDS:

review, management, bibliography, survey, research needs,  
database

DESCRIPTION:

This project was begun in 1984 as part of the Lake Michigan Scoping Study jointly undertaken by the three Illinois Scientific Surveys and sponsored by the Illinois Dept. of Natural Resources, Board of Natural Resources and Conservation. Funding from the Joyce Foundation has allowed the database to be continued and updated.

The objectives of this project are (1) to develop a computerized bibliography of publications on Lake Michigan covering research in biology, chemistry, geology, physical limnology, atmospheric sciences, socio-economics, and management, and (2) to compile a computerized listing of all of the current research projects on Lake Michigan.

This database of projects and publications should be useful to the Great Lakes public and scientific communities in reviewing and coordinating research on Lake Michigan.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 146

HOLM, N.P.; MORGAN, B.

Illinois - Illinois State Geological Survey, Champaign  
Stratigraphy and Surficial Geology Section

GREAT LAKES LAKE TROUT RESEARCH INVENTORY

Starting date: 2/01/1987

Completion date: 7/31/1987

Project no:

Sponsor: Great Lakes Fishery Commission

AREA: Great Lakes; other U.S. lakes; other Canadian lakes

KEYWORDS:

biology, fish, lake trout, survey, review,  
management, database

DESCRIPTION:

This project will compile a computerized listing of current research projects on lake trout in the Great Lakes region. This will aid the Great Lakes Fishery Commission in its efforts to better define and coordinate research and management of lake trout.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 147

HORNS, W.; GORDEN, R.

Illinois - Illinois Natural History Survey, Champaign

SOURCE, FATE, AND ABUNDANCE OF LAKE TROUT EGGS ON  
JULIAN'S REEF

Starting date: 7/01/1986

Completion date: 6/30/1988

Project no:

Sponsor: Illinois Dept. of Conservation

AREA: Julian's Reef; Illinois waters of Lake Michigan

KEYWORDS:

biology, fish, lake trout, eggs, larval fish, substrate,  
spawning, rehabilitation, reefs, habitat, sampling

DESCRIPTION:

This project will examine whether mature lake trout observed aggregating on Julian's Reef are depositing eggs on the reef, whether eggs are deposited on suitable substrates, and what percentage of the deposited eggs survive to emergence. This study should help to evaluate the lake trout stocking strategy.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 148

HORRALL, R.

Wisconsin - University of Wisconsin-Madison  
Marine Studies Center

ARTIFICIAL IMPRINTING OF LAKE TROUT AS A REHABILITATION  
TECHNIQUE

Starting date: 9/01/1986

Completion date: 8/31/1989

Project no: R/LR-34

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Lake Michigan; Wisconsin fish hatcheries

KEYWORDS:

biology, fish, lake trout, reefs, imprinting,  
rehabilitation, spawning, reproduction, homing

DESCRIPTION:

Objectives:

To (1) examine the feasibility of artificial imprinting and decoy techniques to increase the effectiveness of the existing lake trout rehabilitation program; (2) evaluate the potential of several natural and synthetic substances, besides phenethyl alcohol, for use as artificial imprintants; (3) determine the degradation chemistry for phenethyl alcohol and other selected imprintants in aquatic systems; (4) develop techniques for scenting reefs to more effectively attract imprinted fish.

Methodology:

Artificial imprinting (in hatcheries) and decoy (in lakes) techniques, the use of chemosensory imprintants, computer simulations of odor plumes, experimental hatcheries, "Y" mazes and development of constant release devices for imprintants.

Rationale:

Presently, hatchery-reared yearling lake trout being stocked into the Great Lakes are not reproducing successfully. The introduction of artificial imprinting techniques into current hatchery and stocking programs may lead to increased homing to traditional spawning sites, which will enhance natural reproduction and the development of self-sustaining stocks.

Accomplishments:

Manuscript on artificial olfactory imprinting of lake trout is in progress.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 149

HORRALL, R.

Wisconsin - University of Wisconsin-Madison  
Marine Studies Center

STUDIES ON THE EARLY LIFE HISTORY AND RECRUITMENT  
OF FERAL AND NATIVE LAKE TROUT, WITH SPECIAL  
EMPHASIS ON EXPERIMENTALLY PLANTED EGGS AND ALEVINS

Starting date: 9/01/1985

Completion date: 8/31/1989

Project no: R/LR-32

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Lake Michigan; Lake Superior; Black Can Reef; Clay  
Banks; Gull Island Shoal

KEYWORDS:

fish, spawning, reefs, biology, reproduction,  
recruitment, lake trout, eggs, life history,  
alevins, larval fish, imprinting, fish strains

DESCRIPTION:

Objectives:

To (1) continue to operate two experimental lake trout hatcheries; (2) to study the early life history of lake trout which have been experimentally planted on traditional reefs as alevins or as eggs; (3) to study the early life history of native (Gull Island Shoal) and feral (Clay Banks-Black Can) populations of lake trout; (4) to study the behavior of lake trout alevins and fry in the laboratory; (5) to continue to study site imprinting mechanisms in young lake trout.

Methodology:

Techniques include observations by scuba divers, underwater TV, netting gear ("spider" nets, trawls, emergence traps), experimental hatcheries, laboratory aquarium experiments, Y-maze experiments and the use of a very large indoor tank.

Rationale:

Presently, early life history information on lake trout (egg through yearling stages) is inadequate for testing hypotheses concerning the reproductive failure of planted hatchery-reared fish. The early life history of lake trout will be studied in order to better



## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

understand the process of recruitment occurring in native vs. feral stocks.

### Accomplishments:

The Kewaunee and Milwaukee experimental lake trout hatcheries have been filled with 2.2 million eggs of four strains (fall 1985). Preparations are being made to use the Ashland well house for swim-up fry experiments and for the spring (1986) alevin plants on Horseshoe Reef.

### Benefits:

The Great Lakes Fishery Commission and other state and federal agencies charged with lake trout rehabilitation will benefit from the information obtained by this research, the research should provide basic information leading to management decisions that may speed up the development of self-sustaining lake trout stocks in the Great Lakes.



Ref. no. 150

HORRALL, R.; KEILLOR, P.

Wisconsin - University of Wisconsin-Madison  
Marine Studies Center

Wisconsin - University of Wisconsin-Madison  
Sea Grant Institute

FACTORS INFLUENCING THE REESTABLISHMENT OF SELF-  
SUSTAINING STOCKS OF LAKE TROUT IN LAKE MICHIGAN

Starting date: 3/01/1978

Completion date: 8/31/1985

Project no: R/GB-07

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Lake Michigan

KEYWORDS:

fish, biology, reproduction, reefs, imprinting, bioassay,  
behavior, spawning, lake trout, water quality, rehabilitation,  
larval fish, eggs, homing, survival

DESCRIPTION:

Objectives:

- (1) To operate two experimental lake trout hatcheries to bioassay egg and fry survival, study fry behavior and methods of planting eggs and/or sac fry for rehabilitating lake trout on reefs;
- (2) Study homing behavior of lake trout planting on offshore reefs in Green Bay and Lake Michigan;
- and (3) Identify the critical period in lake trout for site imprinting and assess the effectiveness of artificial imprinting in the trout.

Methodology:

Techniques include artificially imprinting lake trout, phenethyl alcohol decoy sites, trap nets, experimental lake trout hatcheries, current and temperature analysis.

Rationale:

This project is designed to investigate some of the possible reasons for the failure of lake trout to reproduce successfully in Lake Michigan - particularly those relating to the behavioral mechanisms of spawning site selection, to different stocking methods and to environmental factors influencing spawning.

Accomplishments:

Incubated over 1.8 million lake trout eggs from several strains in two hatcheries; after hatching, used alevins and fry for behavioral and imprinting and microcontaminant studies and for experimental stocking on reefs to study

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

natural imprinting, natal homing and rehabilitation techniques; completed analysis on current-temperature meter data from three traditional lake trout spawning reefs; published research on the history of brood stocks and the strategy for the use of lake trout strains.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 151

HUBBLE, M.

Illinois - Illinois Dept. of Conservation, Springfield

ILLINOIS WETLANDS INVENTORY

Starting date: 1984

Completion date: Continuing

Project no:

Sponsor: Illinois Dept. of Conservation

AREA: Illinois counties along Lake Michigan shoreline

KEYWORDS:

biology, wetlands, management, aerial photography,  
mapping, survey

DESCRIPTION:

This inventory of the wetland areas along the Illinois shoreline is part of a larger ongoing project conducting an inventory of wetlands in the entire state. The inventory is being done using aerial photography. A field manual is now under preparation.

Ref. no. 152

HUMPHREY, H.

Michigan - Michigan Dept. of Public Health, Lansing

EVALUATION OF FISH FOR PUBLIC HEALTH ADVISORY UPDATE

Starting date: 1985

Completion date: 1985

Project no:

Sponsor: U.S. EPA

AREA: Michigan rivers that lead into Lake Michigan and the  
other Great Lakes; tributaries

KEYWORDS:

biology, fish, human consumption, toxics, PCBs,  
human health, tributaries, organics, chemistry

DESCRIPTION:

The CEHS analytical laboratory will evaluate the presence of organic chemical contaminants in 100 fish collected from rivers which have fish consumption advisories in an effort to determine whether or not such advisories need to be continued or modified.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 153

HUMPHREY, H.; JACOBSEN, J.

Michigan - Michigan Dept. of Public Health, Lansing;

Michigan - Wayne State University, Detroit

EFFECTS OF PBB AND PCB PRE AND POST NATAL EXPOSURE  
ON CHILDREN

Starting date: 1984

Completion date: 1987

Project no:

Sponsor: National Institute of Health (NIEHS)

AREA: Laboratory

KEYWORDS:

biology, fish, human consumption, toxics, PCBs, PBBs,  
human health, organics

DESCRIPTION:

A collaborative research project which links the Michigan PBB exposed (from contaminated dairy products) cohort and PCB exposed (from eating Lake Michigan sport-caught fish) cohort and data base with experts in child behavior and development. The work allows the opportunity to evaluate whether or not PBB or PCB exposure results in subtle differences in a child's development, abilities or behavior and learning.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 154

INDIANA DEPT. OF ENVIRON. MGMT.;

U.S. EPA - REGION V

Indiana - Indiana Dept. of Environmental Management, Indianapolis;

Illinois - U.S. EPA - Region V, Chicago

NORTHWEST INDIANA ENVIRONMENTAL ACTION PLAN

Starting date:

Completion date: Continuing

Project no:

Sponsor: Indiana Dept. of Environmental Management; U.S. EPA  
- Region V

AREA: Indiana; Grand Calumet River; Indiana Harbor Canal;  
Southern Lake Michigan

KEYWORDS:

toxics, chemistry, management, waste disposal,  
water quality, biology, crayfish, invertebrates,  
bioaccumulation, point source, nonpoint source,  
pollutants, sediments, vegetation, fish, loading,  
sediment traps, contaminants, atmospheric,  
inorganics, organics, tributaries, discharge, metals,  
monitoring, air quality, abatement

DESCRIPTION:

The Northwest Indiana Environmental Action Plan is a comprehensive plan which encompasses all programmatic efforts into the full range of ongoing regulatory and investigative activities. Water quality, air quality, and hazardous waste problems will be addressed.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 155

JANSSEN, J.; SAVITZ, J.

Illinois - Loyola University of Chicago  
Biology Dept.

FOOD HABITS OF LAKE MICHIGAN SALMONIDS IN ILLINOIS WATERS

Starting date: 6/01/1983

Completion date: 4/30/1987

Project no: R/F-03

Sponsor: Illinois/Indiana Sea Grant Program

AREA: Illinois waters; Southern Lake Michigan

KEYWORDS:

fish, lake trout, diet, biology, salmonid,  
predation, prey, coho salmon, chinook salmon,  
forage fish

DESCRIPTION:

Objectives:

To (1) determine diet composition of salmonids in the Illinois waters of Lake Michigan on a seasonal and locale basis; (2) determine the relationship between predator size and prey size for the various salmonids; (3) determine condition factors for predators and prey; (4) compare stomach contents with previous studies and concurrent studies for Wisconsin, Michigan, and Indiana waters of Lake Michigan.

Methods:

Sample salmonid stomach contents at least 3 weekends a month at Waukegan, Burnham, Chicago and Evanston Harbors from the end of April until at least mid-Sept. Stomach samples will be preserved in formalin and analyzed in the lab. Lengths and weights of the salmon (before cutting) and the intact prey are recorded for calculation of condition factors.

Accomplishments:

Salmonid stomachs have been collected and analyzed for 1983 to 1986. Most of the salmonines were coho salmon and chinook salmon, with fewer numbers of lake trout, rainbow trout, brown trout, and pink salmon. Coho salmon and chinook salmon showed a similar pattern of diet change over each season with alewives being the almost exclusive early season prey. Alewives were somewhat replaced by yellow perch (YOY) and bloaters later in the season. The diet shift may be due to a seasonal change in prey availability.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 156

JOERES, E.; HUDDLESTON, J.; POTTER, K.;  
SONZOGNI, W.C.; HARKIN, D.

Wisconsin - University of Wisconsin-Madison  
Civil & Environmental Engineering;

Wisconsin - University of Wisconsin-Madison  
Urban and Regional Planning;

Wisconsin - University of Wisconsin-Madison  
Civil & Environmental Engineering;

Wisconsin - University of Wisconsin-Madison  
Water Chemistry Program;

Wisconsin - University of Wisconsin-Madison  
Agricultural Economics

CONSUMPTIVE USE OF GREAT LAKES WATER

Starting date: 9/01/1987

Completion date: 8/31/1990

Project no: R/PS-35

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Lake Michigan; Lake Superior; Lake Huron; Lake Erie;  
Lake Ontario

KEYWORDS:

economics, model, management, water use, hydrology,  
water quality, industry, water budget, diversion,  
review

DESCRIPTION:

Objectives:

To (1) review past efforts, refine the data base and derive accurate estimates of consumptive uses; (2) assess interdependencies among economic activities and geographic subregions; (3) develop an economic model to link the economy to the water resource; (4) estimate water quality and environmental implications of consumptive use.

Methodology:

Utilization of relationships between population, industrial activity levels, energy demand and water use to estimate annual consumptive loss from the Great Lakes; impact assessment via hydraulic/regulatory model modified by P.I.s in previous study.

Accomplishments:

(1) Demonstrated propagation of diversion effects of different hydrologic supply series on water users; (2) quantified errors in hydrologic discharge projections based on inferred measures; (3) made demographic and economic projections for Wisconsin; (4) collaborated with federal/state agencies in the development of

zoning ordinances for shoreland use; (4) worked on ecosystem management strategies for the Great Lakes and assesses impacts of water quantity and water quality relationships; (5) determined equity issues related to transferrable discharge allocations for water pollution control in Great Lakes watershed.

Ref. no. 157

JOERES, E.; POTTER, K.; DAVID, M.

Wisconsin - University of Wisconsin-Madison  
Civil and Environmental Engineering

Wisconsin - University of Wisconsin-Madison  
Civil and Environmental Engineering

Wisconsin - University of Wisconsin-Madison  
Economics

#### MANAGEMENT OF GREAT LAKES WATER

Starting date: 9/01/1982

Completion date: 8/31/1985

Project no: R/PS-30

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Great Lakes

#### KEYWORDS:

model, lake levels, diversion, water use,  
economics, management, value

#### DESCRIPTION:

##### Objectives:

To (1) establish a range of economic valuations for changes in Great Lakes lake levels induced by diversions and consumptive uses; (2) improve upon the techniques for making those valuations by giving consideration to uncertainty attaching to lake levels; (3) bring economic parameters involved in costing benefits up-to-date and develop appropriate schemes for valuing changes in production cost.

##### Methodology:

The project relies heavily on computer models. Simulation of lake levels is achieved by a model developed by the U.S. Army Corps of Engineers. Valuation of economic benefits will involve modification of earlier models in substantive ways.

##### Rationale:

High-value uses for Great Lakes water are emerging in the form of requested extra-basin diversions and in consumptive uses. There is a need for an integrated model to value the effect of diversions and consumptive uses and for integrated policies to allocate water among competing uses. This project deals mainly with the former, but also has implications for latter.

Ref. no. 158

JUDE, D.J.; FUIMAN, L.

Michigan - University of Michigan, Ann Arbor  
Great Lakes Research Division;  
Scotland - DMRL

RELATIVE CONTRIBUTION OF INLAND SPAWNED FISH TO THE  
LAKE MICHIGAN YELLOW PERCH STOCK

Starting date: 2/01/1986  
Completion date: 1/31/1988  
Project no: R/GLF-22  
Sponsor: Michigan Sea Grant College Program

AREA: Lake Michigan; Pigeon Lake; Grand River; Michigan

KEYWORDS:

yellow perch, fish, biology, spawning, tributaries,  
otoliths, age, larval fish, growth, wetlands, habitat,  
recruitment, life history

DESCRIPTION:

Objectives:

To determine the contribution which yellow perch larvae produced in the connecting water bodies of Lake Michigan make to Lake Michigan stocks. Cohort membership for yellow perch individuals at the end of their first growing season will be ascertained using growth history (otoliths), vertebral number, and age as indicators of whether perch were produced in Lake Michigan or connecting water bodies.

Methodology:

We will collect larvae from connecting water bodies and Lake Michigan and establish myomere counts and growth history using otoliths for yellow perch larvae from each environment. At the end of the growing season, young-of-the-year yellow perch will be collected and information gained used to document the proportion of perch in each habitat type.

Ref. no. 159

KANAREK, M.; ANDERSON, H.

Wisconsin - University of Wisconsin-Madison  
Center for Human Systems;

Wisconsin - University of Wisconsin-Madison  
Preventive Medicine

GREAT LAKES FOOD FISH CONTAMINANTS AND  
HUMAN REPRODUCTIVE OUTCOMES

Starting date: 9/01/1986

Completion date: 12/31/1988

Project no: R/GB-26

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Green Bay; Lake Michigan

KEYWORDS:

biology, human health, fish, contaminants, toxics,  
human consumption, PCBs, DDT, DDE, organics, lead,  
inorganics, organochlorine pesticides, diet,  
physiology, risk assessment

DESCRIPTION:

Objectives:

To (1) assess the relationship between contaminated fish consumption and human reproductive outcomes; (2) establish a range of PCB and DDE serum levels in pregnant women from Sept. 1, 1986, through Aug. 31, 1987, in Green Bay, Wisc.; (3) assess the relationship between PCB and DDE serum levels and sport fish consumption; (4) assess the relationship between PCB and DDE serum levels and reproductive outcomes; (5) identify human reproductive risk factors for the Green Bay area.

Methodology:

Prospective epidemiological study; fetal contaminant exposure data obtained by questionnaire; supporting data obtained from maternal and cord blood analyses of PCB and DDE levels; outcome variables obtained from medical and hospital records.

Rationale:

Green Bay fish are contaminated with chlorinated hydrocarbons. About eight percent of local pregnant women eat one or more meals of locally caught fish per week. Do these women have a greater risk of adverse reproductive outcomes than women who do not eat locally caught fish? Can environmental contamination result in human exposures deleterious to human health?

Other Funding Sources:

Funding from the Wisconsin Dept. of Health and

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Social Services 1985-87 biennial toxic laboratory support will be used to evaluate PCB, pesticide, and lead exposure in women who the questionnaire has identified as exposed. The analyses of the maternal and cord blood samples will be performed by the Wisconsin State Laboratory of Hygiene. There will be approximately 500 analyses performed at an anticipated cost of \$90 per analysis. Thus, the total anticipated support by the Wisconsin Dept. of Health and Social Services for this project is approximately \$45,000.



Ref. no. 160

KEAN, W.F.; BURKE, C.D.

Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies;  
Kansas - Wichita State University, Wichita  
Geology Dept.

COMPARISON OF LIMNOMAGNETIC AND LITHOLOGIC  
RECORDS FROM GREEN BAY, WISCONSIN, AND  
LAKE MICHIGAN

Starting date:

Completion date: 1984

Project no:

Sponsor: Sponsor Not Known

AREA: Green Bay; Lake Michigan

KEYWORDS:

geology, sediments, sediment cores, clay,  
sedimentation, historical, deposition,  
lithomagnetic, paleolimnology, stratigraphy

DESCRIPTION:

Three piston cores from the deeper areas of Green Bay indicate in excess of 3.4 meters of post glacial sediments. The sediments were divided into units; Unit I (upper most unit) consists of about 1 meter of soft grey silty clay, Unit II is a more compact dark yellow brown clay, and varies in thickness from 0 to more than two meters. Comparison of the limnomagnetic records between Green Bay and Lake Michigan indicate that the Unit I - Unit II boundary is at approximately 6000 years B.P. In time, this is equivalent to the Lake Forest Member of the Lake Michigan Formation. However, the composition of the Green Bay sediments are significantly different from those of Lake Michigan, and the sedimentation rate for Green Bay appears to be about one half of that for Lake Michigan over the past 6000 to 9000 years B.P.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 161

KENNEDY, J.

Wisconsin - Green Bay Metropolitan Sewerage  
District, Green Bay

DISSOLVED OXYGEN OBSERVATIONS FROM CONTINUOUS MONITORING  
STATIONS AND IN SITU MEASUREMENTS IN THE LOWER FOX RIVER  
AND GREEN BAY

Starting date: 1986

Completion date: 1986

Project no:

Sponsor: Sponsor Not Known

AREA: Fox River; Green Bay; Lake Michigan

KEYWORDS:

chemistry, dissolved oxygen, temperature, sediments,  
water quality, monitoring

DESCRIPTION:

Six continuous recording temperature and dissolved oxygen stations were utilized for water quality monitoring during 1986 in the lower reach of the Fox River and Green Bay. In situ vertical measurements were also collected at 19 stations throughout the lower river and bay on a total of 24 sampling days from June through October. Current DNR effluent limits are structured to maintain 5.0 ppm dissolved oxygen throughout the system. Results of monitoring during 1986 show several periods of dissolved oxygen levels below 5.0 ppm. Of special note is a possible hypolimnetic intrusion on 7/31/86, characterized by low temperature (12.5 degrees C) and oxygen (<1.0 ppm) levels. This water mass was most evident at the northernmost stations (17 miles from the Fox River mouth) and appears to have extended southward to Grassy Island. This condition lasted until mid-August, though exhibiting a widening thermocline and generally northward movement. Continuous monitors showed distinct diurnal and vertical variations, along with oxygen depletions between the De Pere dam and the mouth. Several periods of <5.0 ppm D.O. concentrations were documented, ranging in duration from a few hours to one period of six days.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 162

KENNEDY, J.

Wisconsin - Green Bay Metropolitan Sewerage  
District, Green Bay

CURRENT CONCERNS OF LAKE MICHIGAN CHARTER FISHERMEN

Starting date:

Completion date: 1986

Project no:

Sponsor: Sponsor Not Known

AREA: Lake Michigan

KEYWORDS:

recreation, sport fishing, fish, toxics, survey, salmonid

DESCRIPTION:

Lake Michigan sportfishing has become a major industry in many Wisconsin ports since the introduction of exotic salmonids. The number of charter fishing licenses in Wisconsin has grown from 172 in 1981 to 516 in 1986. In 1985 over 113,000 fish (17% of the total Lake Michigan sport catch) were caught by the Wisconsin charter fleet alone. Success of the salmonid stocking program has stimulated the growth of charter fishing, though the industry suffered a serious setback as a result of the consumption advisory issued in August of 1984 by Wis. Division of Health. Press releases following the advisory emphasized the negative aspects which succeeded in scaring many in the fishing public. Although fish tissue PCB levels continue their downward trend, the general fishing public is still unsure how to assess the actual risk of eating their catch. All charter captains surveyed indicated a loss of business directly due to this issue through 1986. This project examines historical and current charter fishing statistics and examines the effects of outside influences on the industry.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 163

KEOUGH, J.

Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies

ADAPTATIONS OF SCIRPUS VALIDUS TO PHYSICAL FEATURES  
OF THE LAKE MICHIGAN COASTAL ZONE

Starting date: 1984

Completion date: 1986

Project no:

Sponsor: National Science Foundation

AREA: Mink River Estuary; Northern Lake Michigan; Wisconsin  
waters; Laboratory

KEYWORDS:

biology, wetlands, botany, reeds, macrophytes,  
water currents, water depth, growth, genetics, river

DESCRIPTION:

Field studies in the Mink River Estuary in northern Lake Michigan and laboratory flumes are being used to look at the response of *Scirpus validus* to water velocity and water depth. Growth parameters and quality of material are being investigated in 3 populations to compare genotypic and phenotypic responses.

Earlier studies focused on adaptation of the macrophytes to the coastal zone and their distribution and development due to long-term water level fluctuations.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 164

KEOUGH, J.; STEARNS, F.; BROOKS, A.

Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies

DYNAMIC INTERACTION BETWEEN LAKE MICHIGAN AND  
MINK RIVER ESTUARY

Starting date: 1986

Completion date: 1987

Project no:

Sponsor: Wisconsin Academy of Science

AREA: Mink River Estuary, Northern Lake Michigan; Wisconsin  
waters; Rowley Bay

KEYWORDS:

biology, wetlands, botany, food chain, detritus, cattails,  
macrophytes, larval fish, habitat, seiche, particulates,  
zooplankton, phytoplankton, bacteria, fish, river, reeds

DESCRIPTION:

The Mink River Estuary flows into northern Lake Michigan in Rowley Bay. Here, it is a rich interface area. Extensive stands of bulrush, cattail, and burreed provide habitat for larval fish and a number of sport fish. Baseline data is being collected on material and organisms moving back and forth across the interface with the lake- and bay-driven seiches. Documentation of food web material should stimulate further research on this and other Great Lakes estuaries.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 165

KEVERN, N.; ELLIOTT, R.

Michigan - Michigan St. University, East Lansing  
Dept. of Fisheries and Wildlife

## FEEDING HABITS AND GROWTH OF SALMONINES IN EASTERN LAKE MICHIGAN

Starting date: 1983  
Completion date: 1986  
Project no:  
Sponsor: Sponsor Not Known

AREA: Eastern Lake Michigan

### KEYWORDS:

fish, diet, lake trout, salmon, trout, alewife, chub,  
rainbow smelt, yellow perch, forage fish, salmonid,  
biology, populations, predation, size

### DESCRIPTION:

Salmonine utilization of a dynamic forage base, variation in salmonine size at age, and relation between size variation and forage base structure were assessed using angler-caught salmon (*Oncorhynchus tshawytscha*, *Oncorhynchus kisutch*) and trout (*Salvelinus namaycush*, *Salmo gairdneri*, and *Salmo trutta*) from eastern Lake Michigan from 1983-1986. Sampling was done on a regular basis at 15 different ports between New Buffalo and Charlevoix throughout the four-year study. Stomach contents and size characteristics were analyzed for each of 10,670 salmonines sampled. Zooplankton, terrestrial insects, and four species of fish - alewife, bloater chub, rainbow smelt, and yellow perch - were found to be the six dominant forage items. The importance of the fish species other than alewife in the diets parallels reported changes in forage species populations and indicates opportunistic feeding by the predators. Specific findings from these data of diet composition and variation of salmonine size over the four-year study indicate trends that should be considered when assessing the future stability of Lake Michigan's valuable fisheries resource.

Ref. no. 166

KITCHELL, J.F.

Wisconsin - University of Wisconsin-Madison  
Zoology/Center for Limnology

ANALYSIS OF FOOD WEBS ASSOCIATED WITH FISH  
COMMUNITIES IN THE GREAT LAKES

Starting date: 7/01/1985

Completion date: 6/30/1986

Project no:

Sponsor: Great Lakes Fishery Commission

AREA: Great Lakes

KEYWORDS:

biology, fish, diet, food chain, zooplankton,  
forage fish, predation

DESCRIPTION:



Ref. no. 167

KITCHELL, J.F.

Wisconsin - University of Wisconsin-Madison  
Zoology/Center for Limnology

# KEYSTONE PREDATORS IN THE GREAT LAKES

Starting date: 9/01/1980

Completion date: 8/31/1984

Project no: R/LR-17

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Lake Michigan

## KEYWORDS:

fish, biology, model, prey, diet, management,  
sea lamprey, pink salmon, alewife, predation,  
coho salmon, chinook salmon, rainbow trout,  
bioenergetics, salmonid, lake trout

## DESCRIPTION:

### Objectives:

(1) Develop predator-prey models for the lamprey-salmonid-alewife interactions in Lake Michigan;  
(2) determine ecological and physiological parameters needed to apply the model to rainbow trout and pink salmon, potentially important predators; (3) collaborate with other investigators to develop databases for models of other important fishes; (4) conduct a field survey of coho and chinook salmon to determine diet and lamprey attack rates; (5) develop this model as a management tool.

### Accomplishments:

Developed testable model of lamprey attachment time as function of temperature, predator-prey size ratio. Used bioenergetics modeling to predict food consumption and growth, favorably tested against field data. Gathered salmonid stomach samples for two summers. Set up Great Lakes-wide sampling program in second summer. Developed bioenergetic model of salmonid species consumption of alewife and smelt.

### Benefits:

This modeling brings greater understanding of predatory-prey systems in Great Lakes and helps in forecasting results of natural and man-induced changes in these systems. A fish predator-prey model is already being used by state (Michigan DNR) and federal (EPA, Oak Ridge National Laboratory) agencies. in fisheries research and management and studies on bioaccumulation of contaminants. University scientists are also applying models to ongoing research.



Ref. no. 168

KITCHELL, J.F.

Wisconsin - University of Wisconsin-Madison  
Zoology/Center for Limnology

#### SALMONID DIET SURVEY

Starting date: 9/01/1984

Completion date: 8/31/1986

Project no: R/LR-28

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Lake Michigan

#### KEYWORDS:

model, fish, biology, predation, prey, forage fish, alewife, salmonid, populations, diet, chinook salmon, coho salmon, lake trout, smelt, perch, bloater chub, sculpin, bioenergetics

#### DESCRIPTION:

##### Objectives:

To test several hypotheses concerning the predator-prey interaction of Lake Michigan salmonids with their forage base: (1) that alewives will decline in Lake Michigan as the result of salmonid predation; (2) that this will result in a shortage of forage for salmonids; (3) that salmonids will shift to other forage fish as a food source. Also, to define indicators of the intensity of use of the forage resources by predators and compare results to those of other salmonid diet studies on the Great Lakes.

##### Methodology:

Collect and analyze stomach contents of sport-caught salmonids in Lake Michigan. Coordinate similar projects in Minnesota, Illinois-Indiana, Michigan and New York Sea Grant programs and province of Ontario.

##### Rationale:

Evidence suggests that community structure in Lake Michigan is in a period of transition. It is an ideal time to collect information to test hypotheses and to guide management decisions. Sampling sport-caught fish for information in order to assess changes in fish resources and as a basis for development of management plans can be easily accomplished.

##### Accomplishments:

Energetics modeling simulations indicated that

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

40-60% of total annual predation by coho and chinook salmon and lake trout occurs during May through August. During 1982-86, % (wet weight) of alewives in all stomachs examined varied from 70-92% for coho, 80-93% for chinook and 65-92% for lake trout; highest % alewife values for all three species were observed in 1986. The second most important prey fish was smelt, followed by perch, bloaters, and slimy sculpins. Seasonal trends consistently showed greater diet diversity in late summer with Pacific salmon consuming proportionately more smelt and perch, and lake trout consuming more smelt, bloaters, and sculpins. Chinooks consumed large numbers of young perch during upwelling events in Aug. 1985. Absence of a downward trend in % alewives in the diets of these 3 salmonine predators in spite of a major lake-wide decline in the alewife population suggests either a very strong preference for alewives or, perhaps, an underestimation of alewife abundance in Lake Michigan.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 169

KITCHELL, J.F.; BINKOWSKI, F.P.; HEWETT, S.W.  
Wisconsin - University of Wisconsin-Madison  
Zoology/Center for Limnology;  
Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies;  
Wisconsin - University of Wisconsin-Madison  
Center for Limnology

SPECIES INTERACTIONS IN THE GREAT LAKES: COMPLEX  
RECRUITMENT REGULATION FOR ALEWIFE AND PERCH

Starting date: 9/01/1986  
Completion date: 8/31/1990  
Project no: R/LR-35  
Sponsor: University of Wisconsin Sea Grant Institute

AREA: Lake Michigan; Laboratory

KEYWORDS:

biology, fish, alewife, yellow perch, recruitment,  
diet, bioenergetics, predation, prey, populations,  
larval fish, model

DESCRIPTION:

Objectives:

To (1) measure the extent to which predation by yellow perch limits successful recruitment by the alewife population of Lake Michigan; (2) detail the seasonal changes in the predatory-prey relationship between perch and alewife; (3) measure prey vulnerability to different sizes of predators in the lab; (4) use population estimates and bioenergetics models along with the laboratory results to predict population level effects of predation on the recruitment of both species in Lake Michigan.

Methodology:

Techniques and equipment include standard fish lab culture techniques, existing computer models of fish bioenergetics, field fish collections using beach seining and fyke netting, special fish tanks and video camera and recorder.

Rationale:

Lake Michigan's yellow perch, bloater chub and smelt have greatly increased in number in recent years while alewives have declined, yet lake salmonids continue to feed primarily on alewives. The potential of perch predation on larval and Y.O.Y. alewife to limit alewife recruitment needs to be evaluated and the predatory interactions between alewife and perch documented.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 170

KITCHELL, J.F.; HEWETT, S.W.

Wisconsin - University of Wisconsin-Madison  
Center for Limnology

## PREDATOR-PREY MODELS FOR GREEN BAY

Starting date: 9/01/1982

Completion date: 8/31/1984

Project no: R/GB-16

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Green Bay; Lake Michigan

### KEYWORDS:

model, fish productivity, biology, populations,  
bioenergetics, growth, diet, prey, predation

### DESCRIPTION:

#### Objectives:

Assemble and use existing models of fish productivity relative to physical factors to model fish productivity along the north-south gradients in Green Bay; (1) apply existing bioenergetics-based models of fish growth for Lake Michigan at large to the predator-prey interactions in Green Bay; (2) use the model to assess the effects of biotic interactions on fish productivity and how changes in the population of one species effects those of other species.

#### Rationale:

The predator-prey transfer biological energy up the food chain is a key factor in the balance of an aquatic ecosystem. A computer model of the production and interactions of fish in Green Bay would be an invaluable tool in foreseeing the likely outcomes of current trends in bay fish populations.

#### Accomplishments:

This research has built on ongoing studies of the Green Bay fishery and on existing modeling studies of the Lake Michigan fishery.

#### Benefits:

This project will lead to a community-level view of the interactions in the bay. Existing monitoring programs would gain from models indicating which species may be best indicators of the current and future status of bay fish populations and what effects alternate management strategies might have.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 171

KITCHELL, J.F.; HEWETT, S.W.

Wisconsin - University of Wisconsin-Madison  
Center for Limnology

## FISHERY MODELS FOR GREEN BAY

Starting date: 9/01/1984

Completion date: 8/31/1986

Project no: R/GB-24

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Green Bay; Lake Michigan

### KEYWORDS:

model, fish, bioenergetics, biology, growth,  
yellow perch, alewife, walleye, predation, diet,  
management, populations

### DESCRIPTION:

#### Objectives:

To (1) expand our current model into a four compartment model covering the north-south gradient of the bay; (2) continue modeling walleye growth, predation and diet shifts, altered fishing regulations and exploitation levels, and changes in relative abundance of planktivores; (3) model the yellow perch fishery and evaluate strategies for harvesting variable strength year classes; (4) develop small submodels for use by managers and other researchers.

#### Methodology:

Work closely with management agencies and other researchers to develop and test computer models (an interactive population model and a fishery exploitation model) on Apple IIE microcomputers.

#### Rationale:

There is a need to provide flexible management strategies for a multispecies system in the face of complex interactions among species and inherent fluctuations in population abundances. An adaptive management modeling approach will allow managers and researchers to model the effects of alternative methods before choosing specific options and to evaluate current strategies.

#### Accomplishments:

An exploitation model of the Green Bay perch fishery was developed and used. A paper on this model is

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

in press in Fisheries. A more generalized bioenergetics model for fish growth that fish managers can apply to any fish species in any lake is being further developed and will be published by Wisconsin Sea Grant. Model has been given to researchers studying Lake Ontario and other Great Lakes and to scientists elsewhere in the U.S.



# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 172

KITCHELL, J.F.; MILLIMAN, S.; JOHNSON, B.  
Wisconsin - University of Wisconsin-Madison  
Zoology/Center for Limnology;  
Wisconsin - University of Wisconsin-Madison  
Agricultural Economics;  
Wisconsin - University of Wisconsin-Madison  
Zoology/Center for Limnology

## LINKING BIOLOGICAL AND ECONOMIC ANALYSES FOR A GREAT LAKE YELLOW PERCH FISHERY

Starting date: 9/01/1986  
Completion date: 8/31/1988  
Project no: R/GB-27  
Sponsor: University of Wisconsin Sea Grant Institute

AREA: Green Bay; Lake Michigan

### KEYWORDS:

biology, economics, fish, yellow perch,  
policy, recruitment, management, model,  
commercial fishing, sport fishing

### DESCRIPTION:

#### Objectives:

To (1) unite our existing biological and economic models of the Green Bay perch fishery into a single bioeconomic model; (2) use that model to evaluate the effects of Wisconsin DNR policy on biology and economics (commercial and sport); (3) recommend which policy will be most effective in achieving stated goals for Green Bay perch; and (4) provide the model to fish managers as a tool for policy analysis.

#### Methodology:

Join and expand our two existing models, one biological and one economic, of the Green Bay perch fishery. The models were built from data collected in Green Bay, and specifically represent variability seen in recruitment and dockside price for perch.

#### Rationale:

The Wisconsin DNR is attempting to rehabilitate the Green Bay perch fishery through a variable quota and other regulations. The DNR goals are both biologic and economic. Strongly linked in this fishery, both factors are affected by high variability in the system. The DNR needs a tool to evaluate biologic and economic effects of policy options in light of high variability.



## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

### Accomplishments:

A preliminary version of the biological model was the subject of a paper at the 1985 International Association for Great Lakes Research meeting and of a workshop for Green Bay area fish managers. A paper of an early version of the model is in press (Johnson and Stein). Milliman completed his Ph.D. on this topic. Results from the economic model were the subject of a paper at a recent Great Lakes symposium (Milliman and Bishop).

Ref. no. 173

KITCHELL, J.F.; SCAVIA, D.; LANG, G.A.  
Wisconsin - University of Wisconsin-Madison  
Zoology/Center for Limnology;  
Michigan - NOAA/GLERL, Ann Arbor;  
Michigan - NOAA/GLERL, Ann Arbor

# FOOD-WEB REGULATION OF WATER QUALITY

Starting date: 1986  
Completion date: 1986  
Project no: Task 6.48  
Sponsor: NOAA

AREA: Lake Michigan

## KEYWORDS:

biology, chemistry, water quality, eutrophication,  
model, phytoplankton, botany, zooplankton, fish,  
nutrients, phosphorus, inorganics, stratification,  
grazing, food chain, chlorophyll, historical, predation,  
sediments, diatoms, calcium carbonate, primary production,  
top-down control, bottom-up control, sediment cores,  
paleolimnology, predation, year-class strength

## DESCRIPTION:

### Objective:

The overall objective of this task is to evaluate the relative influence of "top-down" and "bottom-up" impacts on Great Lakes water quality. The immediate goals of the task are focused on Lake Michigan and will be addressed through models designed to explore the following hypotheses:

- (1) Summer phytoplankton abundance is determined by epilimnetic phosphorus (P) remaining after the onset of stratification; stratification-period total P concentrations are controlled by the timing of the onset of stratification and thus the duration of spring diatom production.
- (2) Summer phytoplankton composition is controlled by the balance between nutrient supply and zooplankton grazing, both of which are determined by the composition of zooplankton present.
- (3) Variability in controls described in (2) is related to stochastic variation in planktivory (i.e., strong vs. weak fish year classes, etc.) and cascades through the food web in ways that regulate phytoplankton composition and water clarity.
- (4) Variation in planktivory is controlled by piscivory and is therefore subject to regulation through

fisheries management practices.

- (5) By virtue of the relationship between  $\text{CaCO}_3$  precipitation and primary production (i.e., pH influence by primary production) and the potential relationship between fish-predation/zooplankton-structure and primary production, the historical record should offer evidence of correlation between planktivory and both the frequency and intensity of calcite whittings.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 174

KITCHELL, J.F.; STEWART, D.

Wisconsin - University of Wisconsin-Madison  
Center for Limnology

PREDATOR-PREY SYSTEMS IN THE GREAT LAKES

Starting date: 9/01/1984

Completion date: 8/31/1988

Project no: R/LR-29

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Lake Michigan; Great Lakes

KEYWORDS:

model, biology, fish, paleolimnology, sediments,  
bioenergetics, forage fish, salmonid, alewife,  
lake trout, predation, prey, diet, pink salmon,  
competition, zooplankton

DESCRIPTION:

Objectives:

(1) To estimate response characteristics of the Great Lakes trophic system to changes in predation level; (2) to quantify impact on the forage base of predation by various combinations and densities of salmonid predators; (3) to investigate the interactive effect of predation and competition on the resiliency of alewife stocks; (4) to develop paleoecological perspectives that will help create realistic expectations of the carrying capacity of Great Lakes trophic systems.

Methodology:

This study will use computer simulation with bioenergetics models in combination with paleoecological analysis of bottom sediments to recreate and project predator-prey interactions in Lake Michigan.

Rationale:

There is a need to understand predator-prey interactions in Lake Michigan for several reasons: the shifting composition of the forage base for salmonid predators; the alewife's uncertain status; pressure to increase stocking and shift management emphasis to trophy species; and the changing status of lake trout, stream-run salmonids and pink salmon in the lake.

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

### Accomplishments:

Since 1 September 1984: Three papers and one book chapter published or in press; one master's thesis completed; three manuscripts submitted and two others in preparation.

### Benefits:

Information from this study will be useful to those agencies involved in the management of Lake Michigan sport and commercial fishes, especially in the evaluation of alternative stocking policies. It will compliment concurrent studies of forage fishes, salmonid diets and other predator-prey systems in Lake Michigan. The approach can be extended to predator-prey systems in the other Great Lakes and to marine systems.

LAKE MICHIGAN PROJECTS - 1984 -CONTINUING

Ref. no. 175

KLUMP, J.V.; EDGINGTON, D.

Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies

THE USE AND IMPACT OF DREDGE SPOIL MATERIAL  
FOR BEACH NOURISHMENT: A DEMONSTRATION IN  
KEWAUNEE, WISCONSIN

Starting date: 1982

Completion date: 1984

Project no:

Sponsor: Wisconsin Coastal Zone Management; Wisconsin Dept.  
of Natural Resources

AREA: Wisconsin waters; Lake Michigan shore by Kewaunee

KEYWORDS:

geology, dredging, beach, erosion

DESCRIPTION:

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 176

KLUMP, J.V.; KREZOSKI, J.; BOYER, L.F.;  
EDGINGTON, D.

Wisconsin - University of Wisconsin-Milwaukee  
Center for Great Lakes Studies

THE PHYSICAL, CHEMICAL, AND BIOLOGICAL DYNAMICS  
OF THE BENTHIC BOUNDARY LAYER IN GREEN BAY,  
LAKE MICHIGAN

Starting date: 9/01/1984

Completion date: 8/31/1987

Project no: R/GB-22

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Green Bay; Lake Michigan

## KEYWORDS:

biology, chemistry, physical, model, sediments, geochemistry,  
benthic invertebrates, nutrients, cycling, sediment transport,  
diagenesis, oxygen, phosphorus, silica, organic carbon,  
sediment-water interface, water quality, tracer, sediment  
traps, benthic boundary layer, inorganics, iron, manganese,  
trace metals, porewater, regeneration, mixing, nitrogen

## DESCRIPTION:

### Objectives:

(1) Characterize the sediments and benthic invertebrates  
of Green Bay on meaningful scales of time and space, (2)  
Quantify spatial and temporal patterns in sediment transport  
processes, (3) Quantify the biogeochemical coupling between  
benthic and pelagic systems with respect to nutrient cycling,  
oxygen consumption, and the decomposition, diagenesis, and  
burial of carbon, nitrogen, phosphorus, and silica in Green  
Bay sediments.

### Methodology:

Use of a remote sediment profile camera; rare earth element  
particle tracer techniques; an in situ pore water extraction  
probe; benthic flux chambers and Pb-210, Cs-137, Be-7, and  
Rn-222 tracer geochronologies and sediment traps.

### Rationale:

The role of the benthic system as a critical component of  
the Green Bay ecosystem is poorly understood. Much processing  
and cycling of the biologically important elements occurs  
within the sediments, the major sink for the large  
allochthonous loading of nutrients and pollutants to the bay.  
Any plans for water quality improvement must take benthic  
processes into account.

### Accomplishments:

Sites and rates of organic matter deposition, quantification



## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

of the relative amounts of organic carbon regenerated or preserved, extensive pore water profiles for dissolved inorganic carbon, nutrients, Fe and Mn have been measured at 18 stations over the course of three cruises. Rates of sediment-water chemical exchange quantified. Data will allow the construction of sedimentary mass balances in which measured inputs are balanced against measured regeneration and burial rates, and measurement of sediment mixing processes.

LAKE MICHIGAN PROJECTS - 1984 -CONTINUING

Ref. no. 177

KONRAD, J.

Wisconsin - Wisconsin Dept. of Natural Resources, Madison

A RESTRUCTURED ANSWERS MODEL TO BE USED AS A MANAGEMENT  
TOOL IN WISCONSIN

Starting date: 1/1986

Completion date: 4/1987

Project no: R005750-02

Sponsor: U.S. EPA - Great Lakes National Program Office

AREA: Lake Michigan; Fox River; tributaries; Wisconsin

KEYWORDS:

management, water quality, nutrients, chemistry,  
tributaries, watershed, loading, inorganics

DESCRIPTION:

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 178

KRAFT, C.E.; STEWART, D.

Wisconsin - University of Wisconsin-Green Bay  
Sea Grant Office;

Wisconsin - University of Wisconsin-Madison  
Center for Limnology

ALEWIFE CONTRIBUTIONS TO THE PHOSPHORUS DYNAMICS  
IN LAKE MICHIGAN

Starting date: 1986

Completion date: 1987

Project no:

Sponsor: Sponsor Not Known

AREA: Lake Michigan

KEYWORDS:

model, biology, fish, alewife, bioenergetics,  
chemistry, nutrients, phosphorus, inorganics,  
cycling, biomass

DESCRIPTION:

The potential contribution of alewives to the phosphorus dynamics of Lake Michigan was explored using standing stock estimates, an energetics growth model and commercial harvest records. Conservative fall biomass estimates of Lake Michigan alewives from the 1970s account for 3000 metric tons of phosphorus, which is 8% of the total phosphorus available at spring turnover. An energetics model indicates that this alewife population would annually consume invertebrates containing 9700 tons of phosphorus. An estimated 2500 tons of phosphorus would be egested or excreted, which is 50% of the estimated annual sediment losses of phosphorus from the lake. Inclusion of juvenile alewives would more than double these estimates. Recent changes in the Lake Michigan fish community from planktivorous alewives to benthic-feeding fishes could have changed deposition patterns of egested and excreted phosphorus. Commercial and sport fish harvests from Lake Michigan have removed as much as 220 tons of phosphorus from the lake annually.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 179

LAIRD, G.A.; GARDNER, W.S.; SCAVIA, D.  
FAHNENSTIEL, G.L.

Michigan - NOAA/GLERL, Ann Arbor

MECHANISMS OF RELEASE AND UPTAKE OF DISSOLVED  
ORGANIC NUTRIENTS IN LAKE MICHIGAN

Starting date:

Completion date: 1985

Project no: Task 6.35

Sponsor: NOAA

AREA: Lake Michigan

KEYWORDS:

biology, chemistry, nutrients, phytoplankton,  
regeneration, uptake, cycling, phosphorus, organics

DESCRIPTION:

Objectives:

- (1) Estimate release rates of labile dissolved organic nutrients by phytoplankton in Lake Michigan.
- (2) Estimate the quantitative importance of this material to nutrient regeneration in Lake Michigan.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 180

LAIRD, G.A.; SCAVIA, D.  
Michigan - NOAA/GLERL, Ann Arbor

OBSERVATIONS OF LONG-TERM TRENDS IN THE  
PELAGIA OF LAKE MICHIGAN

Starting date: 3/1983  
Completion date: Continuing  
Project no: Task 5.25  
Sponsor: NOAA

AREA: Southeastern Lake Michigan

KEYWORDS:

biology, water quality, chemistry, nutrients, fish,  
predation, zooplankton, phytoplankton, inorganics,  
phosphorus, food chain, eutrophication, chlorophyll,  
top-down control, bottom-up control,  
zooplankton grazing

DESCRIPTION:

Objective:

To monitor water quality and ecological properties  
in Lake Michigan with special emphasis on comparison  
of "top-down" vs. "bottom-up" control.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 181

LANDRUM, P.F.

Michigan - NOAA/GLERL, Ann Arbor

THE EFFECT OF ENVIRONMENTAL FACTORS ON THE  
TOXICOKINETICS OF POLYCYCLIC AROMATIC HYDROCARBONS  
IN PONTOPOREIA HOYI

Starting date: 1/1982  
Completion date: Continuing  
Project no: Task 4.4  
Sponsor: NOAA

AREA: Great Lakes; Laboratory

KEYWORDS:

toxics, chemistry, PAHs, toxicokinetics, organics,  
invertebrates, benthic, biology, sediments, model,  
temperature, distribution, uptake, depuration,  
Pontoporeia, xenobiotics, physiology, Amphipoda

DESCRIPTION:

This project involves the study of environmental parameters such as temperature and seasonal changes in the physiology of Pontoporeia hoyi on the uptake and elimination of organic xenobiotics. The polycyclic aromatic hydrocarbons serve as representative organic pollutants. The data from this study will be used to parameterize a predictive model for the toxicokinetics of organic xenobiotics in P. hoyi.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 182

LANDRUM, P.F.

Michigan - NOAA/GLERL, Ann Arbor

FOOD/SEDIMENT AS A SOURCE OF XENOBIOTICS TO  
PONTOPOREIA HOYI AND HIGHER TROPHIC LEVELS

Starting date: 1984

Completion date: Continuing

Project no: Task 4.7

Sponsor: NOAA

AREA: Laboratory

KEYWORDS:

biology, benthic invertebrates, food chain, Amphipoda,  
Pontoporeia, diet, sediments, xenobiotics, toxics,  
organics, bioaccumulation

DESCRIPTION:

The role of food in the accumulation of organic xenobiotics is uncertain. This work will examine the effect of contaminated food on the toxicokinetics of organic xenobiotics at several levels of the food chain and establish the relative importance of sediments as a source of organic xenobiotics to *P. hoyi*.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 183

LANDRUM, P.F.; FONTAINE, T.D.  
Michigan - NOAA/GLERL, Ann Arbor

ACUTE TOXICITY OF SELECTED ORGANIC XENOBIOTICS TO  
GREAT LAKES INVERTEBRATES

Starting date: 1986  
Completion date: Continuing  
Project no: Task 4.10  
Sponsor: NOAA

AREA: Laboratory

KEYWORDS:

biology, bioassay, toxics, organics, xenobiotics,  
benthic invertebrates, chemistry, model, physiology,  
Pontoporeia, Mysis, Amphipoda, phenol, DDT, carbaryl,  
organochlorine pesticides

DESCRIPTION:

Objectives:

- (1) To determine the acute toxicity of Great Lakes invertebrates to well-studied systemic toxins.
- (2) To develop time, body burden, and toxicity data for parameterizing effects simulation models.
- (3) To initiate the development of a predictive simulation model of the effects of toxic organics.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 184

LANDRUM, P.F.; FREZ, W.A.

Michigan - NOAA/GLERL, Ann Arbor

TOXICOKINETICS OF REPRESENTATIVE POLYNUCLEAR  
AROMATIC HYDROCARBONS IN MYDID RELICTA

Starting date:

Completion date: Continuing

Project no: Task 4.6

Sponsor: NOAA

AREA: Great Lakes; Laboratory

KEYWORDS:

biology, benthic invertebrates, toxics, PAHs,  
organics, Mysid, depuration,  
biotransformation, uptake, metabolism, physiology,  
diet, aquaculture, Pontoporeia, Amphipoda

DESCRIPTION:

Objectives:

- (1) To modify current culture methodology used for maintaining *Pontoporeia hoyi* to maintain mysids.
- (2) To design appropriate modifications of experimental test chambers to expose mysids to polynuclear aromatic hydrocarbons (PAH).
- (3) To determine the uptake, depuration, and biotransformation rate constants for PAH in this invertebrate.
- (4) To determine the extent to which various environmental parameters such as temperature and food type affect the uptake, depuration, and biotransformation rate constants for PAH in *M. relicta*.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 185

LANG, G.A.; EADIE, B.J.  
Michigan - NOAA/GLERL, Ann Arbor

RELATIVE IMPORTANCE OF POLLUTANT LOADINGS

Starting date:  
Completion date: 1984  
Project no: Task 10.19  
Sponsor: NOAA

AREA: Lake Michigan; Lake Superior; Lake Erie; Lake Huron;  
Lake Ontario; tributaries

KEYWORDS:

chemistry, loading, tributaries, river, pollutants,  
nutrients, suspended sediment, chloride, water quality,  
hydrology, inorganics

DESCRIPTION:

Objectives:

To update calculations of U.S. tributary inputs of  
nutrients, suspended sediments, and chloride to each  
of the Great Lakes, and to develop further the  
relationship between tributary flow and pollutant  
loads to the Great Lakes.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 186

LEHMAN, J.

Michigan - University of Michigan, Ann Arbor  
Division of Biological Sciences

FOOD WEB STRUCTURE AND PRODUCTIVITY RELATIONS  
IN LAKES MICHIGAN AND WASHINGTON

Starting date:

Completion date: Continuing

Project no:

Sponsor: Sponsor Not Known

AREA: Lake Michigan; Lake Washington

KEYWORDS:

biology, productivity, nutrients, inorganics, chemistry,  
zooplankton, eutrophication, phytoplankton, loading,  
phosphorus, food chain, Cladocera

DESCRIPTION:

Both Lakes Michigan and Washington have experienced changes in nutrient loading rates and have also been subjected to manipulations at upper trophic levels. The different types of manipulation produce quantitative and qualitative differences in productivity relations and lake metabolism. The success of large-bodied Cladocera in both lakes have produced records of water transparency and reduced algal biomass that surpass the proximate effects of reduced nutrient load on volumetric rates of production. Areal-based rates of production, however, are insensitive to changes in the food web, and seem to vary principally with nutrient load.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 187

LESHKEVICH, G.A.

Michigan - NOAA/GLERL, Ann Arbor

SPECTRAL REFLECTANCE OF GREAT LAKES ICE COVER

Starting date: 1984  
Completion date: Continuing  
Project no: Task 8.12  
Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

physical, ice, meteorology, atmospheric,  
snow, albedos, remote sensing, satellite, Landsat

DESCRIPTION:

Objectives:

- (1) To collect ground and airborne data on the visible and near-infrared spectral reflectance of snow and freshwater ice types and to evaluate the influence of atmospheric conditions and surface metamorphosis on those reflectances.
- (2) To develop methods for estimating area-wide shortwave ice albedos and for identifying different ice types in the Great Lakes ice cover from remotely sensed data using the spectral reflectance field data.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 188

LESHT, B.M.

Illinois - Argonne National Laboratory, Argonne

SEDIMENT RESUSPENSION IN SOUTHERN LAKE MICHIGAN

Starting date: 10/01/1981

Completion date: 9/30/1984

Project no:

Sponsor: NOAA/GLERL

AREA: Southern Lake Michigan

KEYWORDS:

physical, benthic, sediments, resuspension, transport,  
currents, water quality, chemistry, turbidity

DESCRIPTION:

Month-long deployments of an instrument tripod were made to obtain in situ observations of benthic currents and turbidity in the southern basin of Lake Michigan. Sediment resuspension can be parameterized using simple observations.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 189

LESHT, B.M.

Illinois - Argonne National Laboratory, Argonne

BENTHIC BOUNDARY LAYER DATA ACQUISITION SYSTEM  
DEVELOPMENT

Starting date:

Completion date: Continuing

Project no:

Sponsor: NOAA/GLERL

AREA: Great Lakes

KEYWORDS:

physical, benthic boundary layer, sediments, transport,  
currents, water quality, chemistry

DESCRIPTION:

Objective:

To develop instrumentation suitable for study of  
the benthic boundary layer in the Great Lakes.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 190

LESHT, B.M.

Illinois - Argonne National Laboratory, Argonne

BENTHIC NEPHELOID LAYER IN SOUTHERN LAKE MICHIGAN

Starting date: 1985

Completion date: Continuing

Project no:

Sponsor: NOAA/GLERL

AREA: Southern Lake Michigan

KEYWORDS:

physical, nepheloid layer, sediments, transport,  
currents, water quality, chemistry, resuspension,  
nutrients, inorganics, phosphorus, silica

DESCRIPTION:

Objective:

To determine relationships between bottom currents  
and sediment resuspension rates in southern Lake Michigan.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 191

LIEN, G.J.; BIESINGER, K.; ANDERSON, L.;  
LEONARD, E.; GIBBONS, M.

Minnesota - U.S. EPA, Environmental Research Laboratory, Duluth

A TOXICITY EVALUATION OF LOWER FOX RIVER WATER AND SEDIMENTS

Starting date: 1/1985

Completion date: 1/1986

Project no:

Sponsor: U.S. EPA

AREA: Lower Fox River; Green Bay; Lake Michigan

KEYWORDS:

biology, water quality, xenobiotics, organics, toxics,  
chemistry, sediments, bioassay, invertebrates, Ceriodaphnia,  
growth, reproduction, zooplankton, Daphnia, Hyallela, Amphipoda,  
Ephemera, mayfly, Pimephales, fish, fathead minnow, Cladocera

DESCRIPTION:

Many persistent, xenobiotic compounds have been identified in Lower Fox River water, biota, sediment, and effluent discharges, some of which are suspected of adversely affecting aquatic organisms.

Water and sediment samples were collected from the Lower Fox River in late January, mid-March, and late April, 1985. Samples were transported to the Environmental Research Laboratory-Duluth (ERL-D), where a determination of their potential toxicity was accomplished through laboratory bioassays using four freshwater invertebrates and one freshwater vertebrate.

Results from the present toxicity evaluation of Lower Fox River water and sediment indicate a general absence of lethal effects as defined by the bioassays completed within the framework of this study. Significant sublethal effects were recorded in the form of reduced growth or fewer progeny. However, these effects were not observed for more than one species or testing period, and no pattern was evident from this analysis.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 192

LILLESAND, T.

Wisconsin - University of Wisconsin-Madison  
Environmental Remote Sensing Center

MULTIPURPOSE ASSESSMENT OF THEMATIC MAPPER  
DATA FOR COASTAL RESOURCE MANAGEMENT

Starting date: 9/01/1984

Completion date: 8/31/1986

Project no: R/NI-09

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Wisconsin waters of Lake Michigan; Green Bay

KEYWORDS:

remote sensing, eutrophication, mapping, management,  
Landsat, satellite, physical, monitoring, temperature,  
water quality, chlorophyll, turbidity

DESCRIPTION:

Objectives:

To (1) determine the basic spectral and spatial characteristics of landsat thematic mapper (TM) data of Wisconsin's Lake Michigan shore; (2) evaluate use of TM data for coastal resources monitoring; (3) prepare, disseminate and evaluate prototypical cartographics from digital processing of TM data; (4) develop and assess methods for analyzing TM-type satellite data in a micro-processor; (5) develop guidelines for integrating satellite data for coastal resource management.

Methodology:

Use sophisticated image processing hardware and software maintained by the Environmental Remote Sensing Center and mobile precision radiometer whose spectral response is matched to that of the thematic mapper.

Rationale:

The thematic mapper system represents a quantum jump in the technical design and performance of earth resource monitoring satellites. This research will assess the usefulness of data from these systems for an array of coastal monitoring tasks and formulate guidelines for integrating satellite monitoring capabilities into the coastal management process.

Accomplishments:

Developed methods for digital image processing and pursuing geographic information system

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

implementation in a network microprocessor environment. Demonstrated the use of thematic mapper data for predicting secchi disc depths, chlorophyll-a concentrations, turbidity, and temperatures. Obtained significant relationships between satellite and ground data for these parameters. Now developing software for microprocessor analysis of data. Published an experimental TM-based image map and disseminated it to researchers nationwide. Wrote paper describing project for 1986 issue of Photogrammetric Engineering and Remote Sensing.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 193

LILLESAND, T.

Wisconsin - University of Wisconsin-Madison  
Environmental Remote Sensing Center

## SATELLITE REMOTE SENSING OF GREAT LAKES AND COASTAL OCEAN WATER QUALITY

Starting date: 9/01/1986

Completion date: 8/31/1989

Project no: R/NI-10

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Lake Michigan; Green Bay; Wisconsin waters

### KEYWORDS:

physical, remote sensing, satellite, water quality,  
eutrophication, sediment transport, land use, chemistry,  
mapping

### DESCRIPTION:

#### Objectives:

To (1) determine, independently, the applicability of three satellite systems to the monitoring of water quality under Great Lakes conditions; (2) develop guidelines for using these systems in combination to extrapolate conventional water quality measurements made on the Great Lakes; and (3) assess the usefulness of the satellite systems for other coastal management applications (e.g., land use mapping, image mapping, aquatic vegetation mapping, erosion assessment, etc.).

#### Methodology:

Extensive use of specialized image processing hardware and software at U.W.-Madison Environmental Remote Sensing Center; "sea truth" data to be collected by cooperators at U.W.-Green Bay and U.W.-Milwaukee; all models microprocessor-compatible.

#### Rationale:

The three satellite systems to be tested range in capability from 10M spatial resolution (SPOT), to seven-channel (including thermal) spectral resolution (Landsat TM), to twice-daily global coverage (NOAA's AVHRR). The composite potential application of these systems to water quality monitoring under Great Lakes conditions is great and largely unexplored.

#### Benefits:

Information generated by this project would be useful for establishing an operational satellite-based water quality monitoring system for the Great Lakes. Improved understanding of the "big picture" of the physical

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

processes operative in the Great Lakes will be obtained over previously unexplored spatial and temporal scales. The proposed research will establish a scientific foundation on which future satellite systems (e.g., the ocean color imager) could be used under Great Lakes conditions.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 194

LISTON, C.

Michigan - Michigan State University, East Lansing  
Dept. of Fisheries and Wildlife

MONITORING SEA LAMPREY RUNS IN THE ST. JOSEPH RIVER

Starting date: 1984

Completion date: 6/1986

Project no:

Sponsor: U.S. Fish and Wildlife Service

AREA: Michigan; Lake Michigan; St. Joseph River

KEYWORDS:

monitoring, sea lamprey, fish, biology, river, tributaries,  
populations, spawning

DESCRIPTION:

A limited study on indices of abundance of adult sea lamprey runs. Helped U.S.F.W.S. to monitor adult populations, and provided sex ratios and fecundity estimates for the spawning run on the St. Joseph River.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 195

LISTON, C.; BRAZO, D.C.

Michigan - Michigan State University, East Lansing  
Dept. of Fisheries and Wildlife

DISTRIBUTION, PRODUCTIVITY, AND ENERGY RELATIONSHIPS  
OF ADULT FISH IN PENTWATER MARSH

Starting date: 1983

Completion date: 1985

Project no:

Sponsor: Michigan Sea Grant College Program

AREA: Michigan; Pentwater Marsh; eastern shore of Lake  
Michigan

KEYWORDS:

wetlands, productivity, biology, fish, river,  
energy flow, reproduction, populations, distribution

DESCRIPTION:

Population size and productivity estimates for major species were determined. Seasonal distribution and use of Pentwater Marsh by major species were determined. This project provided information on 44 fish species using Pentwater Marsh on Lake Michigan.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 196

LISTON, C.; CHUBB, S.

Michigan - Michigan State University, East Lansing  
Dept. of Fisheries and Wildlife

ABUNDANCE, DISTRIBUTION AND ECOLOGICAL RELATIONSHIPS  
OF LARVAL AND JUVENILE FISHES IN THE PENTWATER MARSH  
ON LAKE MICHIGAN

Starting date: 1/01/1982

Completion date: 1985

Project no: R/CW-13

Sponsor: Michigan Sea Grant College Program

AREA: Michigan; Pentwater Marsh; eastern shore of Lake  
Michigan

KEYWORDS:

fish, populations, wetlands, biology, river,  
productivity, diet, larval fish, distribution

DESCRIPTION:

This project determined the importance of Pentwater Marsh as a nursery area for early life stages of fish. New sampling methods were developed for sampling larval fish. Some 18 taxa of larval fish were collected, and densities were higher than literature values for marine estuaries.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 197

LISTON, C.; KEVERN, N.

Michigan - Michigan State University, East Lansing  
Dept. of Fisheries and Wildlife

MOVEMENTS AND BIOLOGICAL ASPECTS OF WALLEYE  
(STIZOSTEDION VITREUM) IN THE MUSKEGON RIVER AND  
IN MUSKEGON LAKE ON LAKE MICHIGAN

Starting date: 4/1986

Completion date: 9/1987

Project no:

Sponsor: Muskegon Sportfishing Association; Michigan  
Agricultural Exp. Station

AREA: Michigan; Muskegon River; Muskegon Lake; Lake Michigan

KEYWORDS:

fish, populations, walleye, biology, river, tributaries,  
growth, distribution, larval fish, movement, diet,  
productivity

DESCRIPTION:

Objectives:

- (1) Determine movement, distribution, and biology  
of adult walleye in the Muskegon River.
- (2) Determine location, growth, and food habits  
of juvenile walleye in Muskegon Lake.

Ref. no. 198

LIU, P.C.

Michigan - NOAA/GLERL, Ann Arbor

GREAT LAKES WAVE CLIMATE FROM NDBC DATA

Starting date:

Completion date: Continuing

Project no: Task 2.14

Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

physical, buoy, wind, waves, temperature,  
satellite, climate, model

DESCRIPTION:

Objectives:

- (1) To synthesize wave, wind, and temperature data recorded from NDBC NOMAD buoys in the Great Lakes and to delineate climatological information on Great Lakes waves.
- (2) To examine the individual, joint, and multivariate long-term distributions of the parameters and to develop statistical models for representation and prediction.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 199

LOFTUS, A.; KELLER, M.

Michigan - Michigan State University, East Lansing;  
Michigan - Michigan Dept. of Natural Resources, Lansing

EVALUATION OF LAKE TROUT HOOKING MORTALITY IN THE  
UPPER GREAT LAKES

Starting date: 1985  
Completion date: 1986  
Project no: F-53-R, Study 526  
Sponsor: Michigan Dept. of Natural Resources

AREA: Lake Michigan; Lake Huron; Lake Superior

KEYWORDS:

biology, fish, lake trout, monitoring, mortality,  
sport fishing, rehabilitation

DESCRIPTION:

Objectives:

To estimate the hooking mortality rate of lake trout in the Upper Great Lakes and to determine the relationships, if any, between the observed mortality and depth, temperature differential, playing time, length, weight, sex, and gear used.

Justification:

Current lake trout population models indicate excessive mortality to be the cause of failed rehabilitation efforts. In order to reduce the total mortality rates among these fish, the Michigan Dept. of Natural Resources imposed a new set of guidelines, including controversial closed season regulations. The controversy stemmed from angler perceptions that lake trout which were caught and released during this closed season suffered high mortality rates.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 200

LUDWIG, J.

Michigan - Ecological Services Inc., Boyne City

SURVEY OF TERN AND CORMORANT POPULATIONS IN THE  
UPPER GREAT LAKES AREA FOR TOXIC CHEMICAL IMPACTS

Starting date: 5/01/1986

Completion date: 9/31/1986

Project no:

Sponsor: Michigan Dept. of Natural Resources

AREA: Islands in northern Lake Michigan; Green Bay; Lake  
Superior; Lake Huron

KEYWORDS:

biology, birds, toxics, organics, reproduction,  
monitoring, populations, chemistry, common terns,  
cormorants, fecundity, deformity, terns,  
organochlorine pesticides

DESCRIPTION:

This study will survey common tern and cormorant populations on a series of islands in northern Lakes Michigan and Huron, and Lake Superior on four dates between May 15 and July 31, 1986 and collect specimens for archiving and possible chemical analysis.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 329

LYON, J.

Ohio - Ohio State University, Columbus  
Dept. of Civil Engineering

## REMOTE SENSING OF GREAT LAKES WATER RESOURCES

Starting date:

Completion date: Continuing

Project no:

Sponsor: Ohio Sea Grant Program

AREA: Lake Michigan; connecting channels; Lake Erie; Detroit River; Lake St. Clair; St. Mary's River; Straits of Mackinac

### KEYWORDS:

physical, remote sensing, sediment transport, wetlands, lake levels, vegetation, connecting channels, loading, river, satellite, aerial photography, sediments, chemistry

### DESCRIPTION:

Work is being conducted on remote sensing techniques and the use of aerial photography to evaluate coastal and water resources in the Great Lakes Basin. Studies have been conducted on the effects of lake level fluctuations on wetlands, sediment chemistry, and vegetation distribution.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 201

MAC, M.

Michigan - National Fisheries Center - Great Lakes, Ann Arbor

EFFECTS OF PARENTALLY TRANSFERRED CONTAMINANTS ON  
SURVIVAL OF YOUNG LAKE TROUT

Starting date: 6/1984

Completion date: 5/1987

Project no:

Sponsor: U.S. Fish and Wildlife Service

AREA: Lake Michigan; Laboratory

KEYWORDS:

biology, toxics, contaminants, fish, lake trout,  
fry, mortality, PCBs, survival, chemistry,  
organics, diet, reproduction, eggs

DESCRIPTION:

Previous studies designed to examine the survival of lake trout eggs and fry of southeastern Lake Michigan origin have shown near total mortality of the fry. This abnormally high mortality occurs just prior to complete yolk absorption in fry of southeastern Lake Michigan but not in fry hatched from Lake Superior, Lake Huron, or hatchery egg sources. Chemical contaminants inherited from the spawning adults are a likely cause of this mortality. Eggs and sperm from adult hatchery fish fed Lake Michigan forage fish for one year will be taken to measure the influence of the inherited contaminants on fertilization, hatchability, and fry survival. All forage fish and experimentally contaminated eggs and fry will be analyzed for major contaminants and the results evaluated for correlations with measured fry mortality.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 202

MAC, M.; EDSALL, C.C.; HESSELBERG, R.

Michigan - National Fisheries Center - Great Lakes, Ann Arbor

BIOACCUMULATION OF TOXIC SUBSTANCES DURING DREDGING

Starting date: 10/1984

Completion date: 9/1987

Project no:

Sponsor: U.S. Fish and Wildlife Service

AREA: Lake Michigan; Green Bay; Laboratory

KEYWORDS:

pollution, biology, dredging, contaminants, toxics,  
sediments, bioavailability, bioaccumulation, bioassay,  
PCBs, organics, fish

DESCRIPTION:

Field and lab exposures of fish to Green Bay  
sediments demonstrated similar bioaccumulation  
patterns for PCBs and provided an initial  
validation of lab bioassay procedure for use  
in predicting bioaccumulation in the field.  
Additional testing in progress.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 203

MAGNUSON, J.; CLAY, C.S.

Wisconsin - University of Wisconsin-Madison  
Zoology/Center for Limnology;

Wisconsin - University of Wisconsin-Madison  
Geology and Geophysics Dept.

## TROPHIC SIZE CLASS EFFICIENCY OF FISH PRODUCTION IN A GREAT LAKES ESTUARY

Starting date: 9/01/1986

Completion date: 8/31/1988

Project no: R/GB-28

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Green Bay; Lake Michigan

### KEYWORDS:

biology, fish, populations, diet, model, biomass,  
size, benthic invertebrates, Mysis, food chain,  
productivity, energy flow, particle size

### DESCRIPTION:

#### Objectives:

To determine across a trophic gradient (1) the biomass, size and species structure of offshore fishes; (2) the biomass and size structure of major benthic macroinvertebrates; (3) the diets of Mysis and of logarithmically equal size intervals of the major fish taxa; and (4) cooperate with other Sea Grant researchers to test the efficacy of estimating fish biomass from a Sheldon size spectrum and assess the particle-size-conversion efficiency of trophic transfers to fish from plankton and benthos.

#### Methodology:

Biomass and size of fishes will be estimated with sonar and vertical gill nets plus trawls; benthos, by dredge and trawls; plankton, from another Sea Grant project; food web structure by stomach analysis.

#### Rationale:

In the Great Lakes, shallow bays like Green Bay typically yield disproportionately large amounts of fish biomass. Understanding the energy flow through the system by an easily used "yardstick" like particle size will allow more efficient harvest of fishes and provide fisheries scientists with insights on ways to manipulate the bay ecosystem.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 204

MAGNUSON, J.; CROWDER, L.

Wisconsin - University of Wisconsin-Madison  
Center for Limnology;

North Carolina - North Carolina State University, Raleigh  
Zoology Dept.

SPECIES INTERACTIONS AND EARLY LIFE HISTORY DYNAMICS  
OF MAJOR PLANKTIVORES IN LAKE MICHIGAN

Starting date: 9/01/1982

Completion date: 8/31/1984

Project no: R/LR-24

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Lake Michigan

KEYWORDS:

fish, biology, populations, alewife, chub,  
diet, zooplankton, predation, forage fish,  
year-class strength, life history, competition

DESCRIPTION:

This project examined the interactions and ecology of young forage fish (primarily alewife and chub) by comparing how these fish share or compete for food and space, and by assessing the impact that predators have on forage fish populations. With this knowledge, the investigators will then design experiments that will determine the critical factors behind year-class strength.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 205

MAGNUSON, J.; CROWDER, L.; MCDONALD, M.  
Wisconsin - University of Wisconsin-Madison  
Center for Limnology;  
North Carolina - North Carolina State University, Raleigh  
Zoology Dept.;  
Minnesota - University of Minnesota, Duluth  
Natural Resources Research Institute

COMPETITION FOR RESOURCES AMONG LAKE MICHIGAN FORAGE FISHES:  
CONSEQUENCES OF AN ALEWIFE DECLINE

Starting date: 6/01/1984  
Completion date: 8/31/1986  
Project no: R/LR-30  
Sponsor: University of Wisconsin Sea Grant Institute

AREA: Southern Lake Michigan near Grand Haven, Michigan

KEYWORDS:

biology, fish, distribution, temperature, predation,  
alewife, rainbow smelt, habitat, chub, growth, size,  
diet, zooplankton, competition, forage fish, populations,  
yellow perch, benthic invertebrates, Mysis, Pontoporeia,  
prey, year-class strength, Amphipoda

DESCRIPTION:

Objectives:

To (1) repeat bottom trawl survey conducted in August-September 1977,79,80 to assess habitat or diet shifts in this fish community when alewives are relatively rare; (2) analyze fishes caught during earlier studies and in 1984-85 for changes in growth; (3) examine evidence for changes in zooplankton size due to the decline in alewives; (4) examine evidence for reductions in benthic prey available due to the bloater increase; (5) document the decline in size at age for the newly abundant forage fishes and the change in size structure of the alewife populations; (6) determine the age when bloater gill raker metrics stabilize in relation to their shift to the bottom.

Methodology:

Sample fish with bottom trawls along isotherms and in midwater with sonar. Sample zooplankton with nets and benthos with a Smith-MacIntyre dredge. Analyze diets, prey availability and changes in size at age, and shifts in gill raker morphology.

Rationale:

Present conditions offer a unique opportunity to examine the resource use patterns of Lake Michigan forage fish when alewives are rare. Data on these patterns in years

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

when alewives dominated and when alewives and bloater were both abundant will allow comparisons of habitats, diets, growth and gill raker morphology with the current forage fish community under conditions nearly impossible to re-create experimentally.

### Results of macrobenthos part of study:

Declines of approximately 50% in the macrobenthos densities were observed in 1984 relative to previous samples when alewives were the dominant predator. In 1985, the composition of the fish community remained similar to 1984, but overall densities were greatly reduced. Concomitant with decreased densities of fishes, increased densities of macrobenthos were found. This suggests that the Lake Michigan macrobenthos can respond rapidly to changes in predation by the fish community.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 206

MAHONEY, E.; STYNES, D.J.

Michigan - Michigan State University, East Lansing  
Parks and Recreation Dept.

## SEGMENTING AND DEVELOPING DEMAND EQUATIONS FOR MICHIGAN'S SPORT FISHING MARKET

Starting date: 2/01/1985

Completion date: 1/31/1987

Project no: R/R-19

Sponsor: Michigan Sea Grant College Program

AREA: Michigan; Michigan waters of the Great Lakes

### KEYWORDS:

sport fishing, recreation, model,  
marketing, economics, value, survey

### DESCRIPTION:

#### Objectives:

1) To determine whether market segments, especially attributes sought and behavioral segments, remain constant or change throughout the years. 2) To estimate angling origin/destination patterns separately for each segment and estimate the demand, supply and value of sport fishing in Michigan. 3) To test and evaluate market segmentation in relationship in multinomial logit models of angler's choices. 4) To estimate the expenditures by anglers comprising different market segments.

#### Methodology:

One questionnaire developed for the study will provide information on angling origin-destination patterns. Demand and supply equations will be estimated separately for each segment identified in the first year of the study. The segmentation data provide a vehicle for exploring the applicability of logit models to fishing site choices. The questionnaire will collect information on the respondent's last fishing trip including expenditures. This data will be used to determine the expenditure impact of sport fishing in Michigan.



# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 207

MAKAREWICZ, J.

New York - State University of N.Y., Brockport  
Dept. of Biological Sciences

## GREAT LAKES WATER QUALITY SAMPLING

Starting date: 1983

Completion date: Continuing

Project no:

Sponsor: U.S. EPA - Great Lakes National Program Office

AREA: Lake Michigan; Lake Huron; Lake Erie

### KEYWORDS:

water quality, chemistry, nutrients, silica, phosphorus,  
inorganics, phytoplankton, zooplankton, distribution,  
composition, primary production, eutrophication, monitoring

### DESCRIPTION:

For Lake Michigan, open lake water quality samples are being collected at 10 stations south to north on 8-9 different dates to measure nutrient trends and estimate trophic conditions. Nutrient analyses, primary productivity measurements, and identification of phytoplankton and zooplankton are being performed. The distribution and composition of phytoplankton and zooplankton are being related to the phosphorus limitation program in the Great Lakes Basin. Two publications from this work are in press.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 208

MANNY, B.

Michigan - National Fisheries Center - Great Lakes, Ann Arbor

EFFECTS OF NUTRIENT LOADING ON LAKE TROUT  
SPAWNING AND NURSERY HABITAT IN GREAT LAKES WATERS

Starting date: 10/1982

Completion date: 9/1988

Project no:

Sponsor: U.S. Fish and Wildlife Service

AREA: Lake Michigan; Lake Huron

KEYWORDS:

biology, fish, lake trout, habitat, spawning, reefs,  
water quality, eutrophication, detritus, loading,  
sedimentation

DESCRIPTION:

Limnological conditions on historically important lake trout spawning grounds in Lake Huron and Lake Michigan are assessed in order to determine if eutrophication, which has occurred since the native fish stocks were extinguished in the 1940's and 1950's, has adversely affected the intrinsic potential of these areas to support lake trout reproduction. Results to date indicate that accelerated eutrophication and the settling out and decay of lake-produced detrital matter has rendered some historically productive lake trout spawning grounds unsuitable for use.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 209

MANNY, B.; FAHNENSTIEL, G.L.; GARDNER, W.S.

Michigan - National Fisheries Center - Great Lakes, Ann Arbor;

Michigan - NOAA/GLERL, Ann Arbor;

Michigan - NOAA/GLERL, Ann Arbor

## BIOAVAILABILITY OF PRECIPITATION-BORNE PHOSPHORUS TO PHYTOPLANKTON IN THE UPPER GREAT LAKES

Starting date: 1984

Completion date: 1986

Project no:

Sponsor: U.S. Fish and Wildlife Service; NOAA

AREA: Lake Michigan; Laboratory

### KEYWORDS:

nutrients, phosphorus, bioavailability, biology,  
water quality, phytoplankton, precipitation,  
acid rain, atmospheric, tributaries, runoff, bioassay,  
chlorophyll, eutrophication, chemistry, loading,  
pH, rain, inorganics

### DESCRIPTION:

#### Objective:

To determine to what extent phosphorus-starved  
Great Lakes phytoplankton can use phosphorus from  
atmospheric precipitation (normal and acidified).

#### Results:

Laboratory experiments demonstrated that rainwater  
additions to epilimnetic lake water from southeastern  
Lake Michigan stimulated chlorophyll-a production  
during 12- to 20-d incubations. Chlorophyll-a  
production did not begin until 3-5 d after the rain and  
lake water were mixed. Stimulations caused by additions  
of rain acidified to pH 3.0 were usually greater than  
those caused by addition of untreated (pH 4.0-4.5).

Phosphorus in rain was the factor that stimulated  
phytoplankton growth; initial P-33 turnover times were  
significantly correlated with chlorophyll produced.

Atmospheric phosphorus additions are ecologically  
important because rain provides about 25% of the annual  
phosphorus load to offshore waters of Lake Michigan and  
represents nearly all new phosphorus added to offshore  
waters during the summer period of thermal stratification  
and nutrient limitation.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 210

MARANS, R.; BULKLEY, J.

Michigan - University of Michigan, Ann Arbor  
Institute for Social Research;

Michigan - University of Michigan, Ann Arbor  
School of Natural Resources

TRENDS AND EMERGING ISSUES IN GREAT LAKES  
MANAGEMENT: A LONGITUDINAL STUDY

Starting date: 2/01/1985

Completion date: 1/31/1988

Project no: R/RP-04

Sponsor: Michigan Sea Grant College Program

AREA: Great Lakes

KEYWORDS:

policy, economics, management, review, survey

DESCRIPTION:

Objectives:

(1) Investigation of a range of Great Lakes land and water resource relationships via the administration of a detailed survey questionnaire to appropriate units of government. This range of resource relationships will include water quality, coastal resources, toxics, quantity and flows, among others. (2) Compare the results of this survey with baseline data gathered during the 1971/72 survey of governmental bodies with jurisdiction over Great Lakes shoreline. These results will provide a basis for trend analysis as well as for the identification of new and emerging Great Lakes issues.

Methodology:

A questionnaire, similar to one administered to Great Lakes shoreline communities in 1971, will be distributed to about 1200 jurisdictions in the U.S. and Canada in the fall of 1986. The data will provide for the analysis of current issues and practices with regard to resource management and will allow for comparison with the 1971 data. Detailed analysis of the current data, together with trend analysis, will enable the investigators to articulate policy options for decision makers. This will be done through survey feedback, group meetings, and a final report to all communities participating in the study.

Benefits:

1) Preparation and dissemination of survey information to guide in the development of policy alternatives for the Great Lakes. 2) Generation and analysis of data with broad policy applications. 3) Contribution to the Great Lakes data base,

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

a foundation for future trend analysis. 4) Information which should be useful for Great Lakes decision makers, including Great Lakes governors, state and federal legislators, the Great Lakes Commission, and the community of organizations/individuals with policy making authority.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 211

MATSUMURA, F.

Michigan - Michigan State University, East Lansing  
Pesticide Research Center

STUDIES ON THE TOXICOLOGICAL SIGNIFICANCE OF TOXAPHENE  
RESIDUES IN THE GREAT LAKES ECOSYSTEM

Starting date: 1/01/1983

Completion date: 1/31/1986

Project no: R/TS-24

Sponsor: Michigan Sea Grant College Program

AREA: Great Lakes

KEYWORDS:

toxics, fish, toxaphene, biology, chemistry,  
organics, contaminants, water quality, bioassay,  
invertebrates, organochlorine pesticides

DESCRIPTION:

Objectives:

To analyze toxaphene residues in Great Lakes fish and determine their characteristics. To synthesize and isolate toxic toxaphene components (congeners) and establish their presence in the Great Lakes region. To assess the extent of metabolic and other environmental changes and finally to assess the toxicological meaning of the presence of toxaphene residues in Great Lakes ecosystems.

Methodology:

To address the objectives of this study, the toxicity of the toxaphene-like residue will be determined with bioassays using suitable vertebrate and invertebrate species. Also analyses will be done on residues for the presence of the major identified toxicants A, B, and C. Also studied will be the similarity of the toxaphene-like residue with known environmental transformation processes.

Rationale:

The clarification of the presence of toxaphene in the Great Lakes ecosystem is an important environmental and health issue. Users of this data, such as the United States Environmental Protection Agency and the Food and Drug Admin., will be able to make better judgements about the hazards to consumers of fish in the Great Lakes region.



# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 212

MATSUMURA, F.

Michigan - Michigan State University, East Lansing  
Pesticide Research Center

## STUDIES ON THE TOXICOLOGICAL SIGNIFICANCE OF CHLORDANE AND TOXAPHENE RESIDUES IN GREAT LAKES FISH

Starting date: 2/01/1986

Completion date: 1/31/1988

Project no: R/TS-27

Sponsor: Michigan Sea Grant College Program

AREA: Great Lakes

### KEY WORDS:

biology, chemistry, toxics, chlordane, toxaphene,  
fish, salmonid, uptake, biotransformation, tumors,  
biodegradation, lake trout, rainbow trout, brown trout,  
chinook salmon, coho salmon, organics, bioassay, model,  
organochlorine pesticides

### DESCRIPTION:

#### Objectives:

- 1) Analysis of chlordane and toxaphene residues in various tissues of 5 species of Great Lakes salmonids with emphasis on component profiling.
- 2) Acute bioassays to assess the presence of toxic components relative to technical material.
- 3) Neuroreceptor site binding affinity studies to determine the specificity of mode of action.
- 4) Model ecosystem and in vitro biotransformation experiments designed to address relative uptake and biodegradability.
- 5) Advanced assessment of the toxicological relevance of the residue using tests for tumor promoter activity.

#### Methodology:

Methods will include a combination of analytical residue analysis of multiple species and multiple tissues coupled with promoting ability in an in vitro test system to assess the relative toxicologic potency of environmentally derived chlordane and toxaphene residues. Neuroreceptor studies will demonstrate the specificity of the response while in vitro metabolism and laboratory exposures will provide mechanisms for residue composition.

#### Rationale:

This research will provide a sound approach to the relative safety assessment of chlordane



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

and toxaphene residues in Great Lakes fish.

Accomplishments:

Separation and quantification of residues from 1982-1985.

Toxicity assessment of chlordane begun. Paper submitted for 1986 Society of Environmental Toxicology and Chemistry annual meeting. Toxaphene manuscript to be submitted to Archives of Environmental Contamination and Toxicology.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 213

MCCOMISH, T.

Indiana - Ball State University, Muncie  
Biology Dept.

FOOD HABITS OF SALMONIDS IN INDIANA WATERS  
OF LAKE MICHIGAN

Starting date: 4/01/1984

Completion date: 4/30/1987

Project no: R/F-01

Sponsor: Illinois/Indiana Sea Grant Program

AREA: Indiana waters; Southern Lake Michigan

KEYWORDS:

fish, trout, lake trout, diet, biology, salmonid,  
chinook salmon, coho salmon, perch, smelt, alewife,  
chub, forage fish

DESCRIPTION:

Objectives:

To (1) collect salmonid stomach contents and monitor food habits of major salmonids at several sites in Indiana waters of Lake Michigan between April and September, 1986; (2) compare food habits of major salmonids in 1986 with previous data collected in 1984-85 and in the 1970's; (3) provide data to the coordinator of the Great Lakes Sea Grant Network Study on this subject.

Methods:

Salmonids used for food habit evaluation will be caught mainly by sport fishermen in conjunction with fishing derbies at several locations in Indiana waters of Lake Michigan. Fish will be identified, measured, sexed, and weighed at dock side. Food habits will be evaluated in terms of species, date, size, and location of capture. Results of stomach analyses will be compared, as possible, with available forage food items.

Results:

The major forage fish population in 1973 was dominated by alewives (45%), followed by yellow perch (30%) and rainbow smelt (25%). By 1984-86, the forage fish population shifted to dominance by perch (78-86%), followed by smelt (3-18%), bloater chub (2-11%), and alewife (1%). Diet studies conducted in 1970 for coho salmon, chinook salmon, and lake trout revealed alewives as the single dominant forage fish consumed (93-100%). By comparison, the 1984-86 evaluation

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

revealed striking change due to forage base dynamics but continued strong salmonid preference for alewives which composed 33-80% of all diets. Continued salmonid selection of alewives is of concern since alewife abundance is declining. This effect is somewhat mediated by increases in the bloater populations. It is clear that perch are not replacing alewives as a salmonid food in proportion to their current dominance of nearshore forage.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 214

MCCOMISH, T.

Indiana - Ball State University, Muncie  
Biology Dept.

YELLOW PERCH STOCKS IN INDIANA WATERS

Starting date: 1983

Completion date: 1984

Project no:

Sponsor: National Marine Fisheries Institute

AREA: Indiana waters; Southern Lake Michigan

KEYWORDS:

biology, fish, perch, fecundity, age, growth,  
monitoring, diet, populations

DESCRIPTION:

This project assessed the yellow perch populations in the Indiana waters of Lake Michigan. Also did tag study previous years; compared 1973 to the 1984 study.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 215

MCCORMICK, M. J.

Michigan - NOAA/GLERL, Ann Arbor

THERMAL STRUCTURE FORECASTING

Starting date: 1983  
Completion date: Continuing  
Project no: Task 1.7  
Sponsor: NOAA

AREA: Lake Michigan; Lake Superior; Lake Erie; Lake Huron;  
Lake Ontario

KEYWORDS:

model, physical, meteorology, evaporation, climate,  
thermocline, water quality, temperature, mixing

DESCRIPTION:

Objectives:

- (1) To evaluate four representative thermocline models as forecasting tools for predicting temperature profiles in the Great Lakes.
  - (2) To assess the implications of model selection on vertical mixing from a water quality modeling viewpoint.
- A method for predicting thermal structure in lakes will be published in 1986.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 216

MCCORMICK, M.J.

Michigan - NOAA/GLERL, Ann Arbor

VERTICAL DYNAMICS OF TOXIC ORGANICS IN THE GREAT LAKES

Starting date: 1983  
Completion date: Continuing  
Project no: Task 4.5  
Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

model, decomposition, toxics, organics, contaminants, residence time, DDT, PCBs, PAHs, research needs, cycling, atmospheric, partition coefficients, volatilization, thermocline, circulation, physical, chemistry, transport, currents, water quality, air-water interface, diffusion, organochlorine pesticides

DESCRIPTION:

Objectives:

- (1) To develop a mathematical model for predicting the vertical distribution of toxic materials in the Great Lakes.
- (2) To identify research needs and estimate prediction uncertainties by first-order error propagation.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 217

MCCORMICK, M.J.; CAMPBELL, J.E.  
Michigan - NOAA/GLERL, Ann Arbor

GREENHOUSE EFFECTS ON GREAT LAKES TEMPERATURES

Starting date: 1986  
Completion date: 1986  
Project no: Task 1.15  
Sponsor: NOAA

AREA: Lake Michigan; Lake Superior; Lake Huron; Lake Erie;  
Lake Ontario

KEYWORDS:

atmospheric, physical, temperature, carbon dioxide,  
lake levels, evaporation, ice, model, meteorology

DESCRIPTION:

Objectives:

- (1) To predict the long-term effects of increased atmospheric carbon dioxide on the temperature structure of each of the Great Lakes.
- (2) To predict the long-term consequences of changes in the heating cycle on lake levels, evaporation, and ice formation.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 218

MCCORMICK, M.J.; CAMPBELL, J.E.; CLITES, A.H.  
Michigan - NOAA/GLERL, Ann Arbor

LAGRANGIAN EFFECTIVENESS OF SATELLITE-TRACKED  
SURFACE DRIFTERS

Starting date: 1983  
Completion date: 1985  
Project no: Task 1.12  
Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

physical, satellite, currents, wind, waves

DESCRIPTION:

Objectives:

- (1) To estimate gross slippage errors of current drifters used in the Great Lakes.
- (2) To estimate the wind and wave components of slippage errors.
- (3) To estimate patchiness scales and Lagrangian diffusivities from Lagrangian statistics.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 219

MCDONOUGH, M.; COBB, M.

Michigan - Michigan State University, East Lansing  
Park and Recreation Resources

COMMUNITY INTEGRATION INTO GREAT LAKES TOURISM  
INFORMATION NETWORKS

Starting date: 2/01/1985

Completion date: 1/31/1986

Project no: R/R-17

Sponsor: Michigan Sea Grant College Program

AREA: Michigan shoreline; Lake Michigan; Lake Superior; Lake  
Huron; Lake Erie

KEYWORDS:

tourism, sociology, recreation, economics

DESCRIPTION:

This project will compare information networks among tourism businesses along Michigan's shorelines and their relationships to official tourism agencies. Recommendations will be made to tourism businesses on how to best work together to attract more tourists.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 220

MEYERS, P.A.; LEENHEER, M.J.; EADIE, B.J.  
Michigan - University of Michigan, Ann Arbor  
Atmospheric and Oceanic Sciences Dept.;  
Michigan - NOAA/GLERL, Ann Arbor

ORGANIC GEOCHEMISTRY OF SUSPENDED AND SETTLING  
PARTICULATE MATTER IN LAKE MICHIGAN

Starting date:  
Completion date: 1985  
Project no:  
Sponsor: National Science Foundation; NOAA

AREA: Lake Michigan

KEYWORDS:

chemistry, geochemistry, organic matter, transport,  
lipids, particulates, fatty acids, sediments, sediment traps,  
alkanols, sterols, aliphatic hydrocarbons, resuspension,  
nepheloid layer, sediment-water interface, organics,  
sedimentation, degradation, particle size

DESCRIPTION:

Sediment traps at numerous locations in Lake Michigan have provided samples of sedimenting material which have been analyzed for their contents of biomarker fatty acids, alkanols, sterols, and aliphatic hydrocarbons. Processes involved in transforming and transporting organic matter entrained in sedimenting particles have been inferred from the results of these analyses. Near-surface material contains important contributions of land-derived organic matter, presumably of eolian input. Midwater particles have predominantly aquatic organic material of algal origin. At the sediment-water interface, selective suspension of the finer fractions of surficial sediments enriches bottom nepheloid layers with these sediment size classes. As a result, near-bottom particulate matter has an aquatic biomarker character. Organic matter associated with sinking particles undergoes substantial degradation during passage to the bottom of Lake Michigan, and aquatic components are selectively destroyed relative to terrigenous components.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 221

MICHAUD, D.T.; SOHNS, L.E.

Wisconsin - Wisconsin Electric Power Company, Milwaukee

## STABILIZED FLYASH AS ARTIFICIAL REEF CONSTRUCTION MATERIAL

Starting date: 8/01/1981

Completion date: Continuing

Project no:

Sponsor: Wisconsin Electric Power Company

AREA: Lake Michigan

### KEYWORDS:

engineering, artificial reefs, power plants,  
flyash, economics, waste disposal

### DESCRIPTION:

Disposal of coal combustion waste in urbanized areas is a significant problem for many utilities due to limited landfill space near power plants. This situation is stimulating research of environmentally acceptable alternatives to current disposal practices. One alternative receiving consideration is the use of stabilized flyash as artificial reef construction material. Artificial reefs can enhance fish production in freshwater and marine waterbodies which are devoid of natural reefs. The feasibility of constructing flyash block reefs in the marine environment has been established by previous research.

Wisconsin Electric has embarked on a multi-year research program, which, if successful, could result in the construction of numerous flyash block artificial reefs in Lake Michigan.

Completed research of the technical and economic feasibility of constructing flyash block reefs in Lake Michigan continues to be encouraging. Tests to determine the environmental effects of flyash block placement in Lake Michigan are underway.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 222

## MICHIGAN DEPT. OF NAT. RESOURCES

Michigan - Michigan Dept. of Natural Resources, Lansing  
Land and Water Management Division

## GREAT LAKES INFORMATION SYSTEM

Starting date:

Completion date: Continuing

Project no:

Sponsor: Michigan Dept. of Natural Resources

AREA: Michigan; Great Lakes

## KEYWORDS:

geology, mapping, bathymetry, model, database,  
management, land use

## DESCRIPTION:

The Great Lakes Information System has two primary objectives:

- (1) Integrate Great Lakes data and information into a computerized data base which will be used to improve and enhance resource management decisions.
- (2) Identify information gaps and advocate targeted research to provide needed data and information.

The focal point of GLIS is a computerized geographical information system. GLIS also has a strong bibliographic information searching and retrieval capability so that information can be located, cataloged and evaluated for inclusion in the geographical information system.

Mathematical simulation models are being located for use in making resource management decisions and estimating the impacts of various actions affecting the Great Lakes.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 223

MITCHELL, C.; WALKER, S.H.; KELLY, T.K.

Michigan - Grand Traverse Band of Ottawa and Chippewa Indians,  
Suttons Bay

COMMERCIAL FISHING ASSESSMENT

Starting date: 10/1985

Completion date: Continuing

Project no:

Sponsor: Inter-Tribal Fishery Management Program, BIA  
contract

AREA: Northern Lake Michigan; Grand Traverse Bay

KEYWORDS:

biology, fish, lake trout, monitoring, commercial fishing,  
whitefish, forage fish, sport fishing, yellow perch,  
bloater chub, burbot, forage fish, management, biomass,  
growth, populations, mortality, sea lamprey wounding

DESCRIPTION:

The commercial and subsistence fishing catch of all Grand Traverse Bay tribal fishers are monitored and sampled for stock assessment. Other activities include whitefish tagging, forage base studies, and sampling of sport anglers and ice fishers. Species sampled include lake whitefish, lake trout, yellow perch, bloater chubs and all forage species. Burbot sampling will begin this year. This program provides the tribe with biological information and management recommendations necessary to conserve the treaty fishery resource in Grand Traverse Bay and adjacent Lake Michigan.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 224

MORTIMER, C.

Wisconsin - University of Wisconsin-Milwaukee

COUPLING OF PHYSICAL AND BIOLOGICAL DYNAMICS IN  
LARGE LAKES

Starting date:

Completion date: 1985

Project no:

Sponsor: NOAA/GLERL

AREA: Great Lakes

KEYWORDS:

physical, biology, management, monitoring,  
research needs, institutions

DESCRIPTION:

Objective:

To identify gaps in data needed for management actions on lakes, to optimize the design of experimental and monitoring programs, to fill the gaps, and to "listen" to relevant in-lake signals identifying critical responses of the real system.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 225

MORTIMER, C.

Wisconsin - University of Wisconsin-Milwaukee

INTERNAL MOTION AND RELATED INTERNAL WAVES IN  
LAKE MICHIGAN AND LAKE ONTARIO AS RESPONSES TO  
IMPULSIVE WIND STRESSES, PART II.

Starting date:

Completion date: Continuing

Project no:

Sponsor: NOAA/GLERL

AREA: Lake Michigan; Lake Ontario

KEYWORDS:

model, physical, wind, internal waves, seiche, currents

DESCRIPTION:

Objective:

Description of near-inertial period internal waves and  
currents in the lakes in terms of the Poincare wave  
conceptual model.

LAKE MICHIGAN PROJECTS - 1984 -CONTINUING

Ref. no. 226

MUNAWAR, M.; ROSS, P.

Ontario - Canadian Centre for Inland Waters, Burlington  
Great Lakes Fisheries Research Branch  
Illinois - Illinois Natural History Survey, Champaign

NANO-PLANKTON DYNAMICS IN THE NORTH AMERICAN GREAT LAKES

Starting date: 1981  
Completion date: 1984  
Project no:  
Sponsor: Fisheries and Oceans Canada

AREA: Lake Michigan

KEYWORDS:

biology, phytoplankton, water quality, chlorophyll,  
primary production, zooplankton, zooplankton grazing

DESCRIPTION:

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 227

MURPHY, T.

Illinois - DePaul University, Chicago  
Chemistry Dept.

THE DESIGN OF A GREAT LAKES ATMOSPHERIC DEPOSITION AND  
SOURCE NETWORK

Starting date:

Completion date: Continuing

Project no:

Sponsor: U.S. EPA - Great Lakes National Program Office

AREA: Great Lakes

KEYWORDS:

chemistry, monitoring, toxics, organics, atmospheric,  
loading, inorganics, nutrients, water quality, transport,  
meteorology, climate, deposition

DESCRIPTION:

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 228

NALEPA, T.F.

Michigan - NOAA/GLERL, Ann Arbor

DISTRIBUTION OF BENTHIC INVERTEBRATES

Starting date:

Completion date: 1985

Project no: Task 6.8

Sponsor: NOAA

AREA: Lake Michigan

KEYWORDS:

biology, benthic, invertebrates, respiration,  
sediment oxygen demand, bacteria, distribution,  
populations, sediments

DESCRIPTION:

Objectives:

- (1) To determine the quantitative and qualitative distribution of the benthic meiofauna.
- (2) To document both temporal and spatial variations in these populations and examine potential factors causing these variations.
- (3) To determine the vertical distribution of meio- and macrofauna in the sediment and of selected microcrustacea in the sediment-water column.
- (4) To partition the rate of sediment oxygen uptake into its various components and thus determine the relative importance of the bacteria, meio-, and macrofauna in total community respiration.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 229

NALEPA, T.F.

Michigan - NOAA/GLERL, Ann Arbor

LONG-TERM TRENDS IN LAKE MICHIGAN BENTHIC FAUNA

Starting date:

Completion date: Continuing

Project no: Task 6.22

Sponsor: NOAA

AREA: Lake Michigan

KEYWORDS:

biology, benthic, invertebrates, distribution,  
historical, sediments, populations

DESCRIPTION:

Objective:

To determine and interpret long-term trends in the  
benthic fauna of Lake Michigan. Manuscript from this  
project is presently in review.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 230

NALEPA, T.F.

Michigan - NOAA/GLERL, Ann Arbor

FISH ENCLOSURE EXPERIMENTS IN A PROFUNDAL AREA  
OF THE GREAT LAKES

Starting date: 1986

Completion date: Continuing

Project no: Task 6.47

Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

biology, fish, predation, benthic invertebrates,  
populations, food chain, secondary production, abundance

DESCRIPTION:

Objectives:

- (1) Determine the impact of fish predation on benthic invertebrate abundance and composition.
- (2) Obtain quantitative estimates of the transfer of secondary production into fish production.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 231

NALEPA, T.F.; GARDNER, W.S.; QUIGLEY, M.A.  
Michigan - NOAA/GLERL, Ann Arbor

## DISSOLVED PHOSPHORUS RELEASE RATES FROM LAKE MICHIGAN SEDIMENTS AND RELATION TO BENTHIC INVERTEBRATE ABUNDANCES

Starting date: 1984  
Completion date: 12/1986  
Project no: Task 6.36  
Sponsor: NOAA

AREA: Lake Michigan

### KEYWORDS:

biology, benthic invertebrates, populations, sediments,  
nutrients, phosphorus, cycling, inorganics, sediment cores,  
regeneration, chemistry, abundance

### DESCRIPTION:

#### Objectives:

- (1) To obtain phosphorus release rate measurements on intact sediment cores from several locations in Lake Michigan.
- (2) To estimate the quantitative significance, relative to other phosphorus inputs, of sediment phosphorus release in Lake Michigan.
- (3) To determine the relation between sediment phosphorus release rates and benthic invertebrate abundances.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 232

O'LEARY, J.T.; WALLACE, S.J.

Indiana - Purdue University, West Lafayette  
Forestry and Natural Resources Dept.

FACTORS AFFECTING PARTICIPATION IN INDIANA-BASED  
RECREATION ON SOUTHERN LAKE MICHIGAN

Starting date: 4/01/1985

Completion date: 3/31/1987

Project no: R/C-02

Sponsor: Illinois/Indiana Sea Grant Program

AREA: Indiana shoreline of Southern Lake Michigan

KEYWORDS:

management, recreation, tourism, sociology, survey, economics

DESCRIPTION:

This study will focus on participation at public and private recreation facilities along the Indiana shoreline of Lake Michigan. The sample for this mail survey includes 600 randomly-selected people from each of the three lakefront counties in Indiana (Lake, Porter, and LaPorte), as well as 700 people from Cook County in Illinois. The main thrust of the study is to identify any association that may exist between sociodemographic variables of visitors and site attribute factors that influence site selection.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 233

OWEN, R.M.

Michigan - University of Michigan, Ann Arbor  
Atmospheric and Oceanic Sciences Dept.

## A SEDIMENT DISPERSAL MODEL FOR LAKE MICHIGAN

Starting date: 7/01/1987

Completion date: 6/30/1988

Project no: R/ES-01

Sponsor: Michigan Sea Grant College Program

AREA: Lake Michigan

### KEYWORDS:

geology, physical, sediments, sediment transport, model,  
geochemistry, water quality, circulation, mixing

### DESCRIPTION:

#### Objectives:

The primary objective of the proposed research is to apply recently developed geostatistical modelling techniques to the problem of identifying the composition and dispersal pattern of geochemically significant end-members in the surficial sediments of Lake Michigan.

#### Methodology:

Sediments are composed of mixtures of geochemical end-members. The dispersal model will be developed by combining recently developed mathematical techniques capable of 1) isolating a set of sediment parameters which can serve to identify the significant geochemical end-members within the sediments (by end-member compositional Q-mode factor analysis), and 2) resolving the relative amount of each end-member within given mixture of end-members (by a linear programming technique).

#### Rationale:

Because of their low solubilities and/or sorption characteristics, many substances which enter the aquatic environment are rapidly incorporated into the sediments. These sediments are then dispersed and mixed with sedimentary materials from other sources. A knowledge of the actual or potential dispersal patterns of these sediments is critical for making water quality management decisions concerning the location of wastewater outfalls, whether or not pollutants will be trapped in nearshore environments, the effects of mixing with detrital materials from other source areas, and the effects of seasonal variations in circulation patterns.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 234

OWEN, R.M.; LONG, D.T.

Michigan - University of Michigan, Ann Arbor

Atmospheric and Oceanic Sciences Dept.;

Michigan - Michigan State University, East Lansing

Dept. of Fisheries and Wildlife

## GEOCHEMISTRY OF THE SEDIMENT-WATER INTERFACE IN PROFUNDAL LAKE SEDIMENTS

Starting date: 7/01/1987

Completion date: 6/30/1989

Project no: R/ES-02

Sponsor: Michigan Sea Grant College Program

AREA: Lake Michigan; Lake Superior; Lake Huron

### KEYWORDS:

geology, chemistry, geochemistry, nepheloid layer, fluff layer, trace metals, cycling, inorganics, diagenesis, porewater, sediment-water interface, sediments, sodium, lead, mercury, arsenic, aluminum, silica, calcium, magnesium, potassium, chloride, sulfate, sulfur, carbon dioxide, dissolved oxygen, pH, model, nutrients

### DESCRIPTION:

#### Objectives:

The goal of this study is to determine the geochemical processes and rates of reactions occurring at the sediment-water interface in large freshwater lakes.

The first year of study concentrates on Lake Superior and the second year on Lakes Huron and Michigan. The term "geochemistry" refers to the first-row transition elements; the metal group Pb, Hg, and As; selected rare earth elements; pH; dissolved oxygen; carbon dioxide species; the ligands Cl, SO<sub>4</sub>, S<sup>-2</sup>; the cations Ca, Mg, Na, and K; the anions Al and Si. The overall goal will be to 1) determine the origins and roles of the nepheloid layer and fluff layer in controlling elemental cycling at the sediment-water interface; and 2) construct a model for the geochemical cycling of elements across the sediment-water interface.

#### Methodology:

A manned submersible will be used to collect water and sediment samples in five chemical zones of the lake defined by this study: the pre-nepheloid layer, the nepheloid layer, the "fluff" zone, the sediment-water interface, and the column sediments. The chemistry of the waters and the chemistry and mineralogy of the sediments will be measured from which thermodynamic/kinetic models

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

of the systems will be developed.

### Rationale:

At the sediment-water interface the nature of nutrient cycling and the fate of contaminants are determined. There is, however, a dearth of knowledge about this interface in profundal lake sediments compared to what is known about the interface in marine systems. The use of manned submersible will help resolve this problem by affording the detailed study of two important aspects of the sediment-water interface in the Great Lakes: the presence of a nepheloid layer and the chemical gradients at the interface.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 235

PETERSON, R.

Wisconsin - University of Wisconsin-Madison  
School of Pharmacy

## TOXIC HALOGENATED AROMATIC HYDROCARBONS IN LAKE TROUT GAMETES AS A FACTOR OF FRY SURVIVAL

Starting date: 9/01/1987

Completion date: 8/31/1992

Project no: R/MW-40

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Lake Michigan; Laboratory

### KEYWORDS:

chemistry, dioxins, PCBs, organics, toxics, contaminants,  
biology, fish, eggs, reproduction, lake trout, larval fish,  
nutrition, TCDD, synergism, furans, naphthalene,  
dibenzo-p-dioxins

### DESCRIPTION:

#### Objectives:

To determine if: (1) lake trout eggs from Lake Michigan contain toxic halogenated aromatic hydrocarbons; (2) the fry develop a TCDD-like wasting syndrome before death; (3) the cause of wasting is impaired adsorption of yolk sac nutrients, hepatotoxicity, or reduced food intake; (4) TCDD or PCB isomers that are MC-, PB- or mixed-type inducers cause similar toxicity, and (5) combinations of TCDD and PCB isomers act additively to cause fry toxicity.

#### Methodology:

Experimental lake trout hatchery, Biotron facility for TCDD research on aquatic species, body composition methodology, cell culture equipment, HPLC methodology for TCDD metabolites, methodology for enzyme assays (AHH, EROD).

#### Rationale:

Isomers of halogenated aromatic hydrocarbons (biphenyls, dibenzo-p-dioxins, dibenzofurans, naphthalenes) that act by the same mechanism as TCDD but have widely varying potencies may be present in Lake Michigan lake trout gametes in high enough amounts and sufficiently potent in combination to produce a TCDD-like wasting syndrome in fry that ultimately causes death.

#### Benefits:

(1) If this study determines that lake trout reproductive failure is caused by toxic halogenated aromatic hydrocarbons (THAHs) in gametes, it would strongly influence lake trout

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

stocking policies for Lake Michigan; (2) If THAHs act additively to cause fry mortality, regulatory agencies will need to know the total egg burden of THAHs to predict the risk to lake trout reproduction. Inexpensive hepatoma induction assays could screen eggs for total THAH contamination so that expensive isomer-specific GC-MS analyses are only done on "induction positive" samples.



# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 236

PETERSON, R.; LECH, J.

Wisconsin - University of Wisconsin-Madison

School of Pharmacy

Wisconsin - Medical College of Wisconsin-Milwaukee

Pharmacology

## POLYCHLORINATED DIBENZO-P-DIOXINS (PCDDS) AND DIBENZOFURANS (PCDFS): PERSISTENCE AND TOXICITY IN FRESHWATER FISH

Starting date: 1/01/1981

Completion date: 8/31/1987

Project no: R/MW-27

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Laboratory

### KEYWORDS:

rainbow trout, biology, physiology, yellow perch,  
depuration, bioaccumulation, dioxins, TCDD, organics,  
chemistry, contaminants, PCDD, PCDF, dibenzo-p-dioxins,  
dibenzofurans, fish, toxics, bioassay

### DESCRIPTION:

#### Objectives:

To (1) study metabolism of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in ten fish species and identify metabolites; (2) study bioaccumulation, tissue distribution and depuration of TCDD in yellow perch and rainbow trout; (3) study effects of TCDD on histopathology, growth rate and survival in six fish species; (4) study effects of TCDD on immune function and disease resistance in rainbow trout; and (5) study effects of TCDD on reproductive function in rainbow trout.

#### Methodology:

UW biotron facility for TCDD research in fish, high-performance liquid chromatography (HPLC), liquid scintillation counting, and gas chromatography-mass spectrometry (GC-MS).

#### Rationale:

TCDD is a contaminant in fish; but no information exists on its metabolism, bioaccumulation, tissue distribution and depuration study in fish. The information on toxicity deals primarily with lethality. Information on histopathology, growth rate, immune function, disease resistance and reproductive function in TCDD-exposed fish is sparse.

#### Accomplishments:

(1) Developed facility for TCDD research on fish at the U.W. Biotron; (2) showed for the first time that fish



## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

are able to metabolize TCDD; (3) completed bioaccumulation, tissue distribution and depuration study of TCDD in rainbow trout and yellow perch; (4) completed acute toxicity study of TCDD in juvenile perch and trout; (5) completed study on virus disease resistance and immune responses in rainbow trout exposed to TCDD.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 237

PEYTON, R.B.

Michigan - Michigan State University, East Lansing  
Dept. of Fisheries and Wildlife

## AN ANALYSIS OF GREAT LAKES SALMONID ANGLER PREFERENCES AND EXPECTANCIES FOR FUTURE FISHERIES MANAGEMENT PROGRAMS IN LAKE MICHIGAN

Starting date: 7/01/1988

Completion date: 6/30/1989

Project no: R/RP-09

Sponsor: Michigan Sea Grant College Program

AREA: Lake Michigan

### KEYWORDS:

recreation, sport fishing, sociology, management,  
salmonid, fish, angler survey, lake trout, value

### DESCRIPTION:

#### Objectives:

1. Investigate recreational stages and development processes in Great Lakes salmonid anglers.
2. Determine the awareness level, values and beliefs held by Great Lakes anglers regarding Great Lakes fishery issues.
3. Determine representativeness of user input to management decisions.
4. Investigate factors which influence recruitment and drop rates among Great Lakes salmonid anglers.

#### Methodology:

Anglers licensed by the Michigan Dept. of Natural Resources will be surveyed by mail questionnaire. Non-respondents will be sampled and sent abbreviated questionnaires. Field surveys (site intercepts) will be used to further develop questionnaire findings.

#### Rationale:

Both the biology of Great Lakes fish communities and sociology of Great Lakes anglers appear to be in a transition state and neither is well understood. Conflicts in basic philosophy exist between Great Lakes policy setters. Public input to the management process has often been restricted to special interest groups. Great Lakes fishery management could be more effective and face less disruption if representative public input and an understanding of the social/psychological dynamics of anglers were gained. Both the well being of the Great Lakes resource and socio-economic benefits can be enhanced.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 238

PHILIPP, D.P.

Illinois - Illinois Natural History Survey, Champaign  
Aquatic Biology Section

THE ESTABLISHMENT OF A STATE FISHERIES GENETICS PROGRAM  
IN ILLINOIS

Starting date: 10/01/1983  
Completion date: 6/30/1986  
Project no: F-45-R  
Sponsor: Illinois Dept. of Conservation

AREA: Lake Michigan; Jake Wolfe Hatchery; Illinois lakes

KEYWORDS:

biology, fish, lake trout, genetics, biochemistry,  
populations, sport fishing, fish strains

DESCRIPTION:

Objectives:

To establish a program that would be a coordinated effort of Dept. of Conservation (DOC) field biologists, DOC propagation biologists and Natural History Survey fisheries geneticists: 1) to assess the strengths and limitations of specific stocks of largemouth bass in Illinois for propagation and stocking programs, 2) to assess the genetic impact of striped bass and F1 hybrid striped x white bass hybrids on native white bass populations, and 3) to define the genetic composition of all of the species of sportfishes, including lake trout, produced at or procured by the DOC hatchery facilities for comparison with the existing populations in the state.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 239

PHILIPP, D.P.; WHITT, G.S.

Illinois - Illinois Natural History Survey, Champaign  
Aquatic Biology Section

REPRODUCTIVE SUCCESS OF LAKE TROUT ON JULIAN'S REEF,  
LAKE MICHIGAN

Starting date: 6/1986

Completion date: 5/1988

Project no:

Sponsor: Illinois Dept. of Conservation

AREA: Lake Michigan; Julian's Reef; Illinois waters

KEYWORDS:

biology, fish, lake trout, genetics,  
biochemistry, fish strains

DESCRIPTION:

Objectives:

To identify strains of lake trout successfully  
spawning on Julian's Reef through the use of  
isozyme and mtDNA polymorphisms.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 240

QUIGLEY, M.A.

Michigan - NOAA/GLERL, Ann Arbor

PELLETIZATION OF LAKE MICHIGAN SEDIMENTS BY THE  
AMPHIPOD PONTOPOREIA HOYI

Starting date:

Completion date: Continuing

Project no: Task 6.34

Sponsor: NOAA

AREA: Lake Michigan

KEYWORDS:

biology, chemistry, particle size, sediments, benthic,  
invertebrates, Amphipoda, feeding, nutrients, diet,  
regeneration, decomposition, Pontoporeia, cycling,  
coprophagy, fecal pellets, inorganics

DESCRIPTION:

Objectives:

- (1) To identify *P. hoyi* feeding mode (continuous vs. intermittent) throughout individual size classes and season.
- (2) To determine particle size selection and sediment throughout rates of *P. hoyi* feeding in Lake Michigan sediments with respect to how such processes affect nutrient regeneration from sediments to overlying water.
- (3) To describe the fate of *P. hoyi* fecal pellets including decomposition and disintegration rate, incidence of coprophagy, and probability of permanent burial.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 241

QUIGLEY, M.A.; NALEPA, T.F.

Michigan - NOAA/GLERL, Ann Arbor

THE ROLE OF BENTHIC ANIMAL COMMUNITIES IN  
NUTRIENT REGENERATION PROCESSES OF SOUTHERN  
LAKE MICHIGAN

Starting date:

Completion date: 1986

Project no: Task 6.14

Sponsor: NOAA

AREA: Southern Lake Michigan

KEYWORDS:

biology, benthic, invertebrates, nutrients, regeneration,  
sediments, organic carbon, dissolved oxygen, particle size,  
chemistry, cycling, inorganics

DESCRIPTION:

Objectives:

- (1) To determine the extent of nutrient regeneration from nearshore sediments and to evaluate the importance of benthic animal activities in influencing such regeneration.
- (2) To determine the vertical distribution of animals in sediments in relation to vertical profiles of nutrients, dissolved oxygen, organic carbon, water content, and particle-size distribution.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 242

QUINN, F.H.

Michigan - NOAA/GLERL, Ann Arbor

## WATER LEVELS AND FLOWS SIMULATION

Starting date: 10/1985

Completion date: 2/1986

Project no: Task 7.4

Sponsor: NOAA

AREA: Lake Michigan; Lake Superior; Lake Huron; Lake Erie;  
Lake Ontario; Detroit River; St. Clair River; Niagara  
River

### KEYWORDS:

model, physical, water quantity, diversion, inflow,  
precipitation, ice, hydrology, connecting channels,  
lake levels, flow, river, regulation, water quality

### DESCRIPTION:

This task addresses the simulation and special studies aspects of the hydrologic research program. Two models have been developed for use to date. A hydrologic response model for the entire Great Lakes system incorporating the regulation plans for Lakes Superior and Ontario is being used for simulation studies on precipitation augmentation, ice retardation, system diversion, and connecting channel changes. Hydraulic transient models have been developed for the Detroit and St. Clair Rivers incorporating the complete equations for continuity and motion. These models can compute monthly flow rates, flow rates during wind tides and seiches, and flow rates for water quality studies.

In this task small studies will be conducted as the need arises using the hydrologic response model and the hydraulic transient models either separately or in combination. A study is currently underway to determine the contribution of the record 1984 St. Clair River ice jam and the 1985 Niagara River ice jam to the record high lake levels (see Quinn, F.H.; Derecki, J.)



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 243

QUINN, F.H.; AUBERT, E.J.; CROLEY, T.E.  
Michigan - NOAA/GLERL, Ann Arbor

THE WATER SUPPLY OF THE GREAT LAKES: PAST, PRESENT,  
AND FUTURE

Starting date: 1984  
Completion date: 1987  
Project no: Task 7.21  
Sponsor: NOAA

AREA: Lake Michigan; Lake Superior; Lake Huron; Lake Erie;  
Lake Ontario

KEYWORDS:

hydrology, physical, management, water supply,  
water use, historical, regulation, lake levels,  
model

DESCRIPTION:

This task draws together and summarizes in a coherent fashion the factors influencing the water supply and lake levels of the Great Lakes, both natural and anthropogenic, over the last century; it develops a conceptual model of the existing water supply management system and it discusses water supply problems, both present and anticipated. This includes status and trends of lake levels and water supply and demand, what the governments have done to manage the water supply system, and what further actions are needed.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 244

QUINN, F.H.; DERECKI, J.  
Michigan - NOAA/GLERL, Ann Arbor

STUDIES ON THE RECORD ST. CLAIR RIVER ICE JAM  
OF 1984

Starting date: 1984  
Completion date: 1985  
Project no:  
Sponsor: NOAA

AREA: Lake Huron; Lake Michigan; St. Clair River; Lake Erie

KEYWORDS:

physical, winter, ice, lake levels, model,  
flow, navigation, connecting channels, river

DESCRIPTION:

The record breaking St. Clair River ice jam of April, 1984, resulted in major impacts on Great Lakes levels and flows and on navigation throughout the Great Lakes. This study addresses the causes and impacts of the jam. Changes in water levels were measured at a number of sites along Lake St. Clair and the St. Clair River. St. Clair River flows were monitored with two continuously recording EM current meters located in the upper St. Clair River. Following the onset of the jam Lake St. Clair water levels dropped about 60 cm. as the flow was decreased by the jam. The jam had a duration of 24 days. Following the jam breaking on April 29 the waters of Lake St. Clair rose rapidly recovering about 75% of the drop in levels in 4 days.

Computer simulations indicate that it will take at least 3 years for the excess water stored on Lakes Michigan-Huron during the jam to be dissipated and for the levels in those lakes to return to pre-jam conditions. Additionally both Lakes St. Clair and Erie will have higher water levels through 1986 as the stored water drains through them. This ice jam also illustrates the process of natural regulation of the Great Lakes system on the seasonal cycle of levels and flows.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 245

QUINN, F.H.; KELLEY, R.N.

Michigan - NOAA/GLERL, Ann Arbor

UPDATE THE GREAT LAKES HYDROLOGIC DATA BASE, 1981-85

Starting date: 1986

Completion date: Continuing

Project no: Task 7.23

Sponsor: NOAA

AREA: Lake Michigan; Lake Superior; Lake Huron; Lake Erie;  
Lake Ontario

KEYWORDS:

hydrology, database, lake levels, runoff, water quantity,  
model, watershed

DESCRIPTION:

Objective:

The objective of this task is to maintain a hydrologic data base of sufficient quality for both scientific and water resource studies of the Great Lakes.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 246

QUINN, J.P.

Illinois - Loyola University of Chicago  
Dept. of Biology

BIOLOGY OF CRAYFISHES IN SOUTHWESTERN LAKE MICHIGAN

Starting date: 1986  
Completion date: 1987  
Project no:  
Sponsor: Sponsor Not Known

AREA: Southern Lake Michigan; Illinois waters

KEYWORDS:

biology, invertebrates, crayfish, habitat, fecundity,  
benthic, populations, survival, competition

DESCRIPTION:

Two species of crayfish, *Orconectes virilis* (the larger species) and *O. propinquus*, are found in S.W. Lake Michigan in rocky areas 6-15 m deep. Shelters are probably their limiting resource as there is a significant correlation between the number of loose stones (shelters) and number of crayfish per 50 m transect. Both species are recruited at approx. 6 mm, but by fall, *O. virilis* are larger than *O. propinquus*. Adult *O. virilis* are 30-45 mm and *O. propinquus* are 17-30 mm. The number of eggs a female carries is related to the surface area of the tail so larger individuals produce more eggs. *O. virilis* comprises about 20% of total crayfish but about 40% of the eggs and juveniles. When *O. virilis* are in the size range of *O. propinquus* adults their numbers decrease to approximately 20% of the population. *O. propinquus* may displace like size *O. virilis* from shelters leaving them more vulnerable to predation. *O. virilis* then compensates for its lower survivorship by its higher fecundity.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 247

RAKOCZY, G.

Michigan - Michigan Dept. of Natural Resources, Charlevoix  
Charlevoix Great Lakes Fisheries Station

MEASUREMENT OF SPORT FISHING HARVEST IN LAKES MICHIGAN  
HURON, AND SUPERIOR

Starting date: 5/01/1986

Completion date: 4/30/1988

Project no: F-53-R, Study 427

Sponsor: Michigan Dept. of Natural Resources

AREA: Lake Huron, U.S. waters; Lake Superior, U.S. waters;  
Lake Michigan

KEYWORDS:

biology, fish, lake trout, sport fishing,  
monitoring, populations

DESCRIPTION:

Objectives:

To obtain a continuous record of sport catch,  
catch rates, and catch composition in the  
Great Lakes and anadromous fisheries.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 248

RAPPE, C.

Sweden - University of Umea, Umea  
Dept. of Organic Chemistry

ISOMER SPECIFIC ANALYSIS OF GREAT LAKES FISH  
FOR DIOXINS AND FURANS

Starting date: 6/1984

Completion date: 12/1986

Project no:

Sponsor: U.S. EPA - Great Lakes National Program Office

AREA: Lake Michigan; Lake Superior; Lake Huron; Lake Erie;  
Lake Ontario; Lake St. Clair; Netherlands

KEYWORDS:

chemistry, biology, fish, lake trout,  
toxics, PCDD, PCDF, contaminants,  
database, dioxins, furans, organics

DESCRIPTION:

The purpose of this project is to develop a statistically interpretable data base on polychlorinated dibenzo dioxins and furans in the Great Lakes and Midwest fish. Isomer specific analysis of Cl(4)-Cl(8) PCDDs and PCDFs will be performed on 5 samples (5 fish composites) of lake trout each from 10 Great Lakes sites (50 samples), 15 Region V samples (location and species to be decided) and 5 samples from the Netherlands. Project will produce data and reports comparing Great Lakes and Region V with these contaminated European lakes.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 249

RICE, C.P.; MEYERS, P.A.

Michigan - University of Michigan, Ann Arbor  
Great Lakes Research Division;

Michigan - University of Michigan, Ann Arbor  
Atmospheric and Oceanic Sciences Dept.

## PARTITIONING AND CYCLING OF TOXIC ORGANICS IN THE GREAT LAKES ECOSYSTEM

Starting date: 1983

Completion date: Continuing

Project no:

Sponsor: NOAA - Ocean Assessment Division/National Ocean  
Service

AREA: Great Lakes

### KEYWORDS:

chemistry, geochemistry, lipids, sediment traps, PCBs,  
particulates, resuspension, toxics, water quality,  
cycling, organics, dieldrin, suspended sediment,  
sediment-water interface, phthalates, chlorobenzenes,  
DDT, organochlorine pesticides

### DESCRIPTION:

This study is part of a larger study entitled  
"The Cycling of Toxic Organic Substances in the  
Great Lakes Ecosystem" with GLERL/NOAA.

The objective of this project is to study the role  
particle suspension plays in the continued recycling  
of toxic organic compounds in the Great Lakes ecosystem.  
Emphasis is placed on the analyses of the suspended  
and particulate portions of the samples. Both selected  
toxic organics, e.g. pesticides (dieldrin, DDT, etc.),  
PCBs, phthalates, and chlorobenzenes, and nonselective  
GC/MS scans will be performed. Analysis of lipid biomarkers  
of samples will be performed in order to follow  
biogeochemical cycling at the sediment-water and  
epilimnion-hypolimnion interfaces and in other turbidity  
zones, such as river plumes and coastal locations.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 250

RICHARDS, R.P.

Ohio - Heidelberg College, Tiffin  
Water Quality Laboratory

REVIEW OF GREAT LAKES TRIBUTARY SAMPLING STRATEGIES

Starting date: 9/1986

Completion date: 6/1988

Project no: R005918

Sponsor: U.S. EPA - Great Lakes National Program Office

AREA: Lake Michigan; Lake Superior; Lake Huron; Lake Ontario;  
Lake Erie; tributaries; Grand River; Great Lakes Basin

KEYWORDS:

water quality, chemistry, suspended sediment, loading,  
hydrology, runoff, contaminants, sampling, flow,  
pollutants, review, tributaries, watershed

DESCRIPTION:

This project will review and summarize high flow  
tributary data and use this information to develop  
recommendations for tributary sampling strategies for  
the Great Lakes Basin.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 251

RICHMAN, S.; SAGER, P.

Wisconsin - Lawrence University

Biology Dept.;

Wisconsin - University of Wisconsin-Green Bay

Dept. of Science and Environmental Change

THE SIGNIFICANCE OF PELAGIAL TROPHIC STRUCTURE AND  
ENERGY TRANSFER AS DETERMINERS OF EUTROPHICATION

Starting date: 9/01/1985

Completion date: 8/31/1988

Project no: R/GB-29

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Green Bay; Lake Michigan

KEYWORDS:

biology, eutrophication, primary production, fish, predation, phytoplankton, zooplankton, nutrients, chemistry, inorganics, grazing, temperature, nitrogen, silica, phosphorus, light, food chain, diet, top-down control, bottom-up control

DESCRIPTION:

Objectives:

To (1) assess biomass and feeding impacts of pelagial fishes on lower trophic level interactions. Objective 1 will be carried out in a related and coordinated study by J. Magnuson, UW-Madison; (2) measure phytoplankton and zooplankton size-biomass relationships and species composition; (3) measure phytoplankton and zooplankton productivity, grazing and assimilation under in situ conditions; (4) determine vertical profiles of nitrogen, silica, and phosphorus concentrations, and temperature and light conditions. These measurements will be made at three locations in Green Bay with unique trophic conditions.

Methodology:

Radioscope (C-14) will be used to measure phytoplankton productivity and zooplankton grazing rates in situ at different depths in the water column. Water samples for nutrient analysis and plankton species composition and biomass will also be taken.

Rationale:

The project is designed to develop information that will help resolve the question of "bottom-up" (nutrient) vs. "top-down" (predation/herbivory) control of trophic status or primary production in the pelagial ecosystem. This is relevant to Lake Michigan where dramatic induced fluctuations in fish populations have affected zooplankton community structure and subsequently water clarity.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 252

ROBBINS, J.A.

Michigan - NOAA/GLERL, Ann Arbor

RESPONSE OF SEDIMENTS TO LONG-TERM INCREASES IN THE  
CONCENTRATIONS OF CONSERVATIVE SUBSTANCES IN OVERLYING  
WATERS

Starting date:

Completion date: 1985

Project no: Task 3.8

Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

model, physical, chemistry, porewater, sediment cores,  
particulates, strontium, chloride, tritium, inorganics,  
water quality, sediments, radionuclides, tracer,  
trace metals

DESCRIPTION:

Objectives:

- (1) To determine the distribution of conservative substances, such as strontium-90, chloride, and possibly tritium in pore waters of dated sediment cores.
- (2) To develop models that properly describe transport of solutes and particles in sediments and are consistent with the known changes in levels of conservative substances in the water column.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 253

ROBBINS, J.A.  
Michigan - NOAA/GLERL, Ann Arbor

## PARTICLE TRACER MODEL DEVELOPMENT

Starting date:  
Completion date: Continuing  
Project no: Task 3.7  
Sponsor: NOAA

AREA: Great Lakes

### KEYWORDS:

radionuclides, physical, particulates, tracer,  
organics, toxics, behavior, contaminants,  
flux, water quality, transport, chemistry, model,  
sediment traps, sediments

### DESCRIPTION:

#### Objectives:

- (1) To obtain optimal estimates of the flux of radionuclides and stable element tracers to the Great Lakes.
- (2) To develop a one-dimensional (horizontally averaged) model describing the seasonal behavior of particle-associated tracers in the water column.
- (3) To develop two-dimensional (vertically averaged) and whole, well-mixed lake box) models describing the long-term time-dependence of radiotracer concentrations in the lakes.
- (4) To interface models with those describing the behavior of organic contaminants.
- (5) To calibrate models on the basis of known distribution of radiotracers in water, trap materials, and sediments.
- (6) To use the models to predict distributions of tracers and to develop optimum field strategies.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 254

ROBBINS, J.A.; EADIE, B.J.

Michigan - NOAA/GLERL, Ann Arbor

## PRESENT AND HISTORICAL RECORDS OF CONTAMINANT FLUXES IN HIGH SEDIMENTATION AREAS OF THE GREAT LAKES

Starting date:

Completion date: Continuing

Project no: Task 3.5

Sponsor: NOAA

AREA: Great Lakes

### KEYWORDS:

chemistry, historical, sediment cores, flux, toxics, contaminants, sedimentation, mixing, bioturbation, radionuclides, inorganics, organics, model, deposition, sediments, transport, degradation, water quality, trace metals

### DESCRIPTION:

#### Objectives:

- (1) To make precise determinations of sedimentation rates, ages of individual layers of sectioned sediment cores, and ranges and rates of biogenic mixing using radiometric methods.
- (2) To determine the concentration of selected elements and inorganic and organic chemical compounds in dated sediment sections.
- (3) To develop models that quantitatively describe the history of deposition of contaminants and take into account processes such as transport and degradation within the sediment column.
- (4) To use models to estimate the flux of contaminants from sediments into overlying water.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 255

ROBBINS, J.A.; WHITE, D.S.

Michigan - NOAA/GLERL, Ann Arbor;

Michigan - University of Michigan, Ann Arbor

ROLE OF ZOOBENTHOS IN VERTICAL SEDIMENT TRANSPORT

Starting date:

Completion date: Continuing

Project no: Task 3.6

Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

model, biology, chemistry, sediments, transport, inorganics, nutrients, deposition, mixing, radionuclides, particulates, bioturbation, benthic invertebrates, water quality, sedimentation

DESCRIPTION:

Objectives:

- (1) To determine rates of sediment reworking by natural benthos populations.
- (2) To relate benthic densities and reworking rates to sedimentation and nutrient deposition rates.
- (3) To relate the vertical distribution of zoobenthos to sedimentation and mixing parameters determined radiometrically.
- (4) To quantify the effects of benthos-mediated particle reworking on transport of solutes.
- (5) To develop mathematical models of the effects of benthos on particle and solute transport in sediments.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 256

ROSS, P.; RISATTI, J.; HENEBRY, M.

Illinois - Illinois Natural History Survey, Champaign;  
Illinois - Illinois State Geological Survey, Champaign;  
Illinois - Illinois Natural History Survey, Champaign

## ASSESSMENT OF ECOTOXICOLOGICAL HAZARD OF WAUKEGAN HARBOR SEDIMENTS

Starting date: 1985

Completion date: 8/1986

Project no:

Sponsor: University of Illinois Hazardous Waste Res. and  
Info. Center

AREA: Waukegan Harbor; Lake Michigan; Illinois waters

### KEYWORDS:

biology, toxics, chemistry, organics, bacteria, bioassay,  
sediments, PCBs, protozoan, phytoplankton, nematodes,  
invertebrates, contaminants, metals, inorganics,  
risk assessment, degradation

### DESCRIPTION:

This study will assess, in both chemical and biological terms, the potential risks associated with contaminants that have accumulated in the sediments of Waukegan Harbor. There are 4 main tasks:

- 1) Sediment will be sampled on a grid of 20 stations and the concentrations of metals and PCB will be determined. These data will be used to generate computerized distribution maps for all contaminants detected, and dispersal patterns will be identified by spatial autocorrelation techniques.
- 2) Toxicity tests using bacterial, algal, and nematode species will be performed on extractions of sediment samples for comparison.
- 3) In addition, a community-level bioassay (Protozoan colonization) will be carried out in situ. These tests will be used to determine which areas of the harbor might present especially high environmental risks to the ecosystem. Benthic insect larvae and small fish (if populations are sufficient) collected from the site will be assayed to establish biofactors for selected pollution.
- 4) Lab measurements of the rates of anaerobic degradation of PCBs will be performed to establish the residence time of these compounds in undisturbed sediments.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 257

ROSSMANN, R.

Michigan - University of Michigan, Ann Arbor  
Great Lakes Research Division

AN ASSESSMENT OF THE QUALITY OF WATER TRACE METAL DATA FOR  
THE GREAT LAKES AND ESTABLISHMENT OF NEW BASELINE DATA

Starting date: 9/01/1981

Completion date: 6/30/1984

Project no:

Sponsor: U.S. EPA

AREA: Lake Michigan; Green Bay; Lake Erie

KEYWORDS:

chemistry, water quality, trace metals, inorganics,  
silver, aluminum, arsenic, barium, beryllium, bismuth,  
cadmium, cobalt, copper, iron, mercury, lithium, manganese,  
molybdenum, nickel, lead, antimony, selenium, tin, strontium,  
vanadium, zinc, historical

DESCRIPTION:

Water samples were collected from the open waters  
of Lake Michigan, including Green Bay, and from Lake Erie  
for analysis of total and dissolved concentrations of trace  
metals. Historical data were summarized and evaluated.  
The 1982 data is presented in the following publication:  
Rossmann, R. 1984. Trace Metal Concentrations in the  
Offshore Waters of Lakes Erie and Michigan. Spec. Rep.  
No. 108, Great Lakes Res. Div., University of Michigan.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 258

ROSSMANN, R.

Michigan - University of Michigan, Ann Arbor  
Great Lakes Research Division

DETERMINATION OF PRESENT AND HISTORICAL FLUXES IN  
HIGH SEDIMENTATION RATE AREAS OF THE GREAT LAKES

Starting date:

Completion date: 8/31/1986

Project no: DOC-C-NA-81-RAH-00003

Sponsor: NOAA

AREA: Southern Lake Michigan

KEYWORDS:

sediment cores, sedimentation, flux, historical, mixing,  
trace metals, diagenesis, oxygen, water quality, sediments,  
mercury, cadmium, lead, inorganics, deposition

DESCRIPTION:

Sediment cores collected from southern Lake Michigan have been dated and analyzed for a variety of trace metals, including mercury, cadmium, and lead. The time variation of mass flux of each metal contaminants to southern Lake Michigan is being estimated.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 259

ROSSMANN, R.; RICE, C.P.; SIMMONS, M.S.;  
JUDE, D.J.

Michigan - University of Michigan, Ann Arbor  
Great Lakes Research Division

COLLECTION AND POLLUTANT ANALYSES (GC/MS AND METALS)  
OF NEARSHORE GREAT LAKES FISHES

Starting date: 5/01/1983  
Completion date: 11/30/1984  
Project no: EPA-G-R-005736-01  
Sponsor: U.S. EPA

AREA: Nearshore of Lake Michigan

KEYWORDS:

biology, chemistry, metals, inorganics, carp,  
bowfin, northern pike, rock bass, smallmouth bass,  
fish, PCBs, chlordane, toxics, river, tributaries,  
contaminants, organochlorine pesticides, organics

DESCRIPTION:

Fish were collected from 14 river mouths and embayments of nearshore Lake Michigan. The largest size class of each species was analyzed for metal and organic pollutants. Two species were analyzed from each site. The major species analyzed included common carp, bowfin, northern pike, rock bass, and smallmouth bass.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 260

RYBICKI, R. W.

Michigan - Michigan Dept. of Natural Resources, Charlevoix  
Charlevoix Great Lakes Fisheries Station

ASSESSMENT OF LAKE TROUT POPULATIONS IN THE TREATY  
AREA OF LAKE MICHIGAN

Starting date: 1984

Completion date: 1989

Project no: F-35-R, Study 432

Sponsor: Michigan Dept. of Natural Resources

AREA: Lake Michigan near Pentwater and Frankfort, Michigan;  
Little Traverse Bay; Grand Traverse Bay; Good Harbor Bay

KEYWORDS:

biology, fish, lake trout, mortality, commercial fishing,  
monitoring, sport fishing, survival

DESCRIPTION:

Objectives:

To calculate survival rates, standing stock,  
and total allowable yield for lake trout in  
treaty area.

Justification:

Significant natural recruitment of lake trout  
has not materialized, despite annual plantings  
since 1965. A major part of the problem may be  
excessive harvest by both sport and commercial  
interests. The Lake Michigan Lake Trout Technical  
Committee has recommended that the annual survival  
rate be not less than 60%. This means that survival  
estimates must be fairly precise so that harvest  
quotas can be set accordingly.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 261

RYBICKI, R. W.

Michigan - Michigan Dept. of Natural Resources, Charlevoix  
Charlevoix Great Lakes Fisheries Station

EVALUATION OF LAKE TROUT PLANTED EXPERIMENTALLY  
IN THE REFUGE AREA OF NORTHERN LAKE MICHIGAN

Starting date: 1986

Completion date: 1996

Project no:

Sponsor: Michigan Dept. of Natural Resources

AREA: Lake Michigan; Beaver Island area

KEYWORDS:

biology, fish, lake trout, survival, growth,  
reproduction, monitoring, reefs, fish strains,  
lake trout rehabilitation

DESCRIPTION:

Objectives:

To evaluate the survival, growth, and reproduction  
of lake trout stocked experimentally in a refuge area  
of northern Lake Michigan.

Justification:

Some 750,000 yearling lake trout, equally divided  
between three strains, are to be stocked annually  
in the northern refuge on several reefs historically  
known to have been lake trout grounds; the multi-  
strain planting is to begin in 1986 and continue for  
at least 10 consecutive years.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 262

SALAMUN, P.J.; SUMMERFIELD, M.

Wisconsin - University of Wisconsin-Milwaukee  
Botany Dept.

COMPOSITION AND PRODUCTIVITY OF AQUATIC MACROPHYTE  
COMMUNITIES IN THREE LAKE MICHIGAN BAYS

Starting date: 6/01/1980

Completion date: 8/31/1984

Project no: R/LR-23

Sponsor: University of Wisconsin Sea Grant Institute; Center  
for Great Lakes Studies; University of  
Wisconsin-Milwaukee graduate school

AREA: Lake Michigan; Moonlight Bay; North Bay; Rowley Bay;  
Door County; Wisconsin waters

KEYWORDS:

biology, botany, wetlands, productivity, cattails,  
macrophytes, Typha, trace metals, inorganics, uptake,  
distribution, biomass, nutrients, vegetation,  
chemistry

DESCRIPTION:

This project involved the examination of distribution patterns, biomass, and plant tissue analyses of submerged macrophytes and nutrient analyses of the water in three bays in Door Co., Wisconsin. This research was performed as part of the Ph.D. dissertation of M. Summerfield entitled "Distribution and productivity of the submerged aquatic macrophytes of three bays of Lake Michigan, Door Co., Wisconsin", and work of two other graduate students.

Among other findings: no rare or endangered macrophytes exist in these bay marshes; aquatic plants zonation in bays differs from that of inland lakes; abundance of some species varies from year to year.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 263

SAVITZ, J.; JANSSEN, J.

Illinois - Loyola University of Chicago  
Biology Dept.

## ANALYSIS OF THE BEHAVIOR BASES FOR CHANGES IN SALMONID DIETS

Starting date: 4/01/1985

Completion date: 4/30/1987

Project no: R/F-04

Sponsor: Illinois/Indiana Sea Grant Program

AREA: Lake Michigan

### KEYWORDS:

biology, fish, diet, salmonid, behavior, forage fish,  
alewife, prey, predation, coho salmon, rainbow trout,  
chinook salmon, yellow perch, smelt, bloater chub,  
fathead minnow, habitat

### DESCRIPTION:

#### Objectives:

To determine how foraging behavior of salmonids  
influences prey selection by:

1. comparing salmonid hunting strategies on  
individual prey and schools of prey
2. determining reactive distances of prey to  
salmonid approach and pursuit
3. comparing prey escape strategies.

#### Methods:

Foraging behavior of coho salmon, chinook salmon,  
and rainbow trout have been recorded by video  
cassette and supplementary visual observations at  
different densities of single prey species and  
different proportions of two prey species. The prey  
species were alewives, yellow perch, smelt, a few  
bloaters, and fathead minnows. Nearly 70 hours of  
video recordings have been collected and data on  
reactive distance, swimming speeds, acceleration  
rates of salmonids and prey have been analyzed.

#### Rationale:

With decreasing alewife populations, a shift to  
alternate species should occur for continued good  
growth of salmonids and subsequent fisherman  
harvest. The behavioral bases for a shift in prey  
species was examined.

#### Accomplishments:

From video camera and visual observations, it was  
determined that prey selection was based on the



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

habitat the prey utilized. Salmon foraged at mid-water levels and usually did not attempt to capture prey on the bottom or sides of the aquarium. They did attempt to capture prey at the surface but usually failed. Chinook and coho salmon were excellent pelagic foragers and were capable of attaining attack speeds greater than 4m/sec. Alewives probably have continued as the principal forage because they occupy a habitat that the salmon also utilize and salmon have little difficulty capturing them.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 264

SAVITZ, J.; JANSSEN, J.

Illinois - Loyola University of Chicago  
Biology Dept.

PREY HANDLING TIMES FOR LAKE MICHIGAN SALMONIDS

Starting date: 4/01/1984

Completion date: 12/31/1984

Project no: R/F-02

Sponsor: Illinois/Indiana Sea Grant Program

AREA: Illinois waters of Lake Michigan

KEYWORDS:

fish, predation, biology, prey, salmonid, diet, size,  
rainbow trout, coho salmon, chinook salmon, lake trout,  
alewife, smelt, bloater chub, yellow perch, forage fish

DESCRIPTION:

Objectives:

To (1) determine handling time curves for salmonid  
predators (coho salmon, chinook salmon, lake trout,  
and rainbow trout) for certain Lake Michigan forage  
fishes (alewife, smelt, bloater, and yellow perch);  
(2) determine what size of prey are relatively immune  
to salmonid predation.

Methods:

The salmonids are available at the Shedd Aquarium.  
Prey species will be obtained by gill netting off  
of Loyola University of Chicago. A variety of prey  
and predator sizes will be used. Handling time is  
the time from when the prey is grasped until the  
last swallowing is detected.

Benefits:

To be able to predict what sizes of particular  
prey species are relatively immune to salmonid  
predation and enhance the interpretation of  
stomach analysis data being done around the  
Great Lakes.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 265

SAYLOR, J.H.; MILLER, G.S.  
Michigan - NOAA/GLERL, Ann Arbor

ROTATIONAL MODE EXPERIMENT

Starting date: 1982  
Completion date: Continuing  
Project no: Task 1.8  
Sponsor: NOAA

AREA: Southern Lake Michigan

KEYWORDS:

waves, physical, currents, wind, circulation

DESCRIPTION:

Objective:

To study the seasonal circulation of southern Lake Michigan and the properties of long-period vorticity waves in the lake's basins.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 266

SAYLOR, J.H.; MILLER, G.S.

Michigan - NOAA/GLERL, Ann Arbor

## LAKES ENVIRONMENT BENTHIC BOUNDARY LAYER EXPERIMENTS

Starting date: 1984

Completion date: Continuing

Project no: Task 1.11

Sponsor: NOAA

AREA: Great Lakes

### KEYWORDS:

benthic boundary layer, model, currents, sediments,  
physical, resuspension, sediment transport, particulates,  
chemistry, water quality

### DESCRIPTION:

#### Objectives:

- (1) To investigate and test available equipment for measuring currents, sediment concentrations, and other important parameters necessary for parameterization of bottom material resuspension and near-bottom sediment transport processes.
- (2) To quantify the distribution of bottom current intensities as functions of both space and time in order to parameterize the distribution and frequency of resuspension events.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 267

SCAVIA, D.; FAHNENSTIEL, G.L.  
Michigan - NOAA/GLERL, Ann Arbor

LAKE MICHIGAN ECOSYSTEM EXPERIMENT--PLANKTON AND  
PARTICULATE LOSS RATES

Starting date:  
Completion date: 12/1986  
Project no: Task 5.18  
Sponsor: NOAA

AREA: Lake Michigan

KEYWORDS:

biology, phytoplankton, zooplankton, particulates,  
nutrients, sinking rates, flux, bacteria, loss rates,  
zooplankton grazing, inorganics, phosphorus, chemistry

DESCRIPTION:

Objectives:

- (1) To measure vertical flux of planktonic algae and particulate nutrients on variable time scales (hours-weeks) for the purpose of determining loss from specific vertical strata.
- (2) To determine loss rates of algae (community and populations) due to zooplankton grazing.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 268

SCAVIA, D.; LAIRD, G.A.

Michigan - NOAA/GLERL, Ann Arbor

LAKE MICHIGAN ECOSYSTEM EXPERIMENT--BACTERIAL GROWTH AND  
LOSS RATES

Starting date: 3/1984

Completion date: 1986

Project no: Task 5.19

Sponsor: NOAA

AREA: Lake Michigan

KEYWORDS:

biology, bacteria, growth, loss rates,  
organic carbon, zooplankton grazing

DESCRIPTION:

Objective:

To determine growth and grazing loss rates of  
planktonic bacteria for the purpose of comparing  
bacterial carbon growth requirements to algal  
organic carbon release rates.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 269

SCAVIA, D.; LAIRD, G.A.  
Michigan - NOAA/GLERL, Ann Arbor

HETEROTROPHIC MICROBIAL FOOD WEBS

Starting date: 1987  
Completion date: Continuing  
Project no: Task 5.26  
Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:  
biology, bacteria, heterotrophy, food chain

DESCRIPTION:



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 270

SCAVIA, D.; LANG, G.A.; FAHNENSTIEL, G.L.; LAIRD, G.A.  
Michigan - NOAA/GLERL, Ann Arbor

LAKE MICHIGAN ECOSYSTEM EXPERIMENT--SYSTEM SYNTHESIS  
AND MODELING

Starting date:  
Completion date: 12/1986  
Project no: Task 5.17  
Sponsor: NOAA

AREA: Lake Michigan

KEYWORDS:

model, phytoplankton, zooplankton, biology, nutrients,  
grazing, growth, sinking rates, bacteria, photosynthesis,  
water quality, inorganics

DESCRIPTION:

Objective:

To combine process measurements made in the  
other NOAA/GLERL Ecosystem Experiment projects in  
a model of plankton dynamics and test prediction  
against observed changes for the purpose of evaluating  
models and experimental coverage of natural processes.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 271

SCAVIA, D.; LANG, G.A.; FONTAINE, T.D.  
Michigan - NOAA/GLERL, Ann Arbor

ECOSYSTEMS MODELS FOR THE GREAT LAKES

Starting date: 1987  
Completion date: Continuing  
Project no: Task 5.27  
Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

biology, model, food chain, phytoplankton, botany,  
zooplankton, bacteria, invertebrates, benthic,  
nutrients, cycling, inorganics

DESCRIPTION:

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 272

SCAVIA, D.; MALCZYK, J.M.; GARDNER, W.S.  
Michigan - NOAA/GLERL, Ann Arbor

LAKE MICHIGAN ECOSYSTEM EXPERIMENT--AMBIENT CONDITIONS

Starting date:  
Completion date: 12/1986  
Project no: Task 5.22  
Sponsor: NOAA

AREA: Lake Michigan

KEYWORDS:

biology, nutrients, chemistry, physical, cycling,  
phytoplankton, zooplankton, bacteria, water quality,  
inorganics, phosphorus, temperature, mixing

DESCRIPTION:

Objectives:

To measure ambient chemical, biological, and physical  
conditions and changes during ecosystem experiment and  
interpret changes in terms of nutrient cycling.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 273

SCHELSKE, C.; STOERMER, E.F.

Michigan - University of Michigan, Ann Arbor  
Great Lakes Research Division

PALEOLIMNOLOGY IN DEPOSITIONAL ZONES OF LAKE MICHIGAN

Starting date: 1983

Completion date: Continuing

Project no:

Sponsor: National Science Foundation (1983-1985); University  
of Michigan (1986)

AREA: Lake Michigan

KEYWORDS:

diatoms, silica, biology, geology, fossils, historical,  
sediments, deposition, nutrients, paleolimnology, phosphorus,  
geochemistry, phytoplankton, inorganics, eutrophication

DESCRIPTION:

The chronology of biogenic silica and microfossil accumulation is being studied in Lake Michigan sediments to determine changes in chemical and biological characteristics in post-European settlement period. Specifically, the research is directed to determining how historic phosphorus inputs have affected the biogeochemistry of silica and the major biological organisms (diatoms) which are the biological link in this process. Work in progress indicates that drastic changes have occurred in periods on the order of decades.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 274

SCHENKER, E.; MAYER, H.; HEILMANN, R.

Wisconsin - University of Wisconsin-Milwaukee  
School of Business Administration;

Wisconsin - University of Wisconsin-Milwaukee  
Geography Dept.;

Wisconsin - University of Wisconsin-Milwaukee  
Management Research Center

## GREAT LAKES TRANSPORTATION IN THE 1980S

Starting date: 9/01/1982

Completion date: 8/31/1984

Project no: R/PS-31

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Great Lakes

### KEYWORDS:

shipping, ports, economics, transportation

### DESCRIPTION:

#### Objectives:

To perform a comprehensive analysis of factors affecting the Great Lakes transportation system such as the increasing cost and decreasing availability of energy, the prospects of reaching the physical capacity of the seaway, rising costs of seaway tolls and the likelihood of increased user fees for harbor dredging.

#### Accomplishments:

A book entitled "Great Lakes Transportation in the 1980s" has been published from the results of this project. Developed a database for predicting future of Great Lakes maritime trade, which entails fewer but more specialized ports, more bulk commodity and less general cargo.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 275

SCHNEIDER, A.

Wisconsin - University of Wisconsin-Parkside, Kenosha  
Division of Science

STRATIGRAPHY OF LATE WISCONSINAN DEPOSITS  
IN SOUTHEASTERN WISCONSIN

Starting date: 1982

Completion date: Continuing

Project no:

Sponsor: University of Wisconsin-Parkside

AREA: Lake Michigan; Wisconsin shoreline

KEYWORDS:

geology, historical, lake levels, glacial,  
stratigraphy, carbon-14, dating

DESCRIPTION:

See Hansel et al. (ref. no. 129) for description of  
collaborative studies.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 276

SCHWAB, D.J.

Michigan - NOAA/GLERL, Ann Arbor

PREDICTION OF WIND-GENERATED WAVES ON THE  
GREAT LAKES

Starting date:

Completion date: 1986

Project no: Task 2.13

Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

model, waves, wind, physical

DESCRIPTION:

Objectives:

- (1) Develop a parametric wave prediction model and implement it within the framework of the GLERL numerical modeling system developed in Task 1.1.
- (2) Test the model in a hindcast mode against field data gathered in Tasks 2.12, 2.14. this task and NDBC buoy data.
- (3) To test the model in a forecast mode against NOAA/NWS operational wave forecasts.
- (4) To implement the model for operational use if it proves superior to current forecast methods.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 277

SCHWAB, D.J.

Michigan - NOAA/GLERL, Ann Arbor

GENERAL NUMERICAL MODELS FOR COMPUTING CURRENTS

Starting date:

Completion date: Continuing

Project no: Task 1.1

Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

model, physical, currents, circulation, water quality,  
transport, suspended sediment, pollutants

DESCRIPTION:

Objective:

The objective of this task is to develop and verify a hierarchy of improved water quality and circulation models that will predict the transport of suspended or dissolved substances in the Great Lakes. In doing this, we will develop general numerical methods that can be applied to other physical problems, such as ice and wave prediction.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 278

SCHWAB, D.J.; CLITES, A.H.; CAMPBELL, J.E.;  
LYNN, E.W.

Michigan - NOAA/GLERL, Ann Arbor

SPILL MODEL VERIFICATION USING SATELLITE-TRACKED  
DRIFTER BUOYS

Starting date:

Completion date: Continuing

Project no: Task 1.10

Sponsor: NOAA

AREA: Lake Michigan

KEYWORDS:

model, oil spill, satellite, currents,  
physical, water quality

DESCRIPTION:

Objectives:

- (1) To verify the improved general-purpose spill model using data from satellite-tracked drifter buoys.
- (2) To analyze the existing drifter buoy data base in conjunction with Vector Averaging Current Meter (VACM) data collected in Lake Michigan concurrently.
- (3) To study the surface current patterns for specific areas of interest using satellite-tracked drifter buoys.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 279

SEEGERT, G.

Illinois - EA Science & Technology, Northbrook

SPAWNING MOVEMENTS OF SKAMANIA TROUT

Starting date: 1984

Completion date: Continuing

Project no:

Sponsor: Sponsor Not Known

AREA: Lake Michigan; Little Calumet River; Salt Creek; Burns Harbor drainage; Burns Ditch; tributaries; Indiana waters

KEYWORDS:

biology, rainbow trout, fish, movement, spawning, temperature, thermal plume, thermal pollution, temperature effects, distribution, monitoring

DESCRIPTION:

In an attempt to determine whether the thermal plume from a steel mill was causing Skamania (rainbow) trout to avoid the Little Calumet River, electrofishing surveys were done at five zones in the Cal-Burns Harbor drainage. Avoidance was found in 1984. Data in 1985 were insufficient for detailed analysis. Further studies are planned for 1987.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 280

SHABICA, C.

Illinois - Northeastern Illinois University, Chicago  
Earth Science Dept.

OFFSHORE PROFILES ALONG SOUTHERN LAKE MICHIGAN SHORELINE

Starting date: 1985

Completion date: 1986

Project no:

Sponsor: City of Highland Park; Northeastern Illinois  
University

AREA: Southern Lake Michigan; Illinois waters

KEYWORDS:

geology, mapping, lake levels, hydrography, bathymetry

DESCRIPTION:

This projects involves bathymetric profiling  
from the shoreline to the 25 ft. isobath for:

1. Highland Park, Illinois (1985)
2. Glencoe, Winnetka, Kenilworth (1986)

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 281

SHABICA, C.; BADER, R.; PRANSCHKE, F.

Illinois - Northeastern Illinois University, Chicago  
Earth Science Dept.

EVIDENCE OF LAKE CHIPPEWA LOW WATER STAGE  
IN LAKE MICHIGAN

Starting date: 1980

Completion date: 1985

Project no:

Sponsor: Northeastern Illinois University

AREA: Southern Lake Michigan; Illinois waters

KEYWORDS:

geology, historical, glacial, lake levels, sediment cores,  
paleolimnology, pollen, carbon-14, dating, sediments,  
sedimentology, lake stages

DESCRIPTION:

Twenty gravity cores were collected from deep water along an E-W transect, east of Waukegan, IL. The three upper members of the Lake Michigan formation were examined for paleontological and sedimentological evidence for the Lake Chippewa low water stage.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 282

SHEDLOCK, R.J.

Indiana - U.S. Geological Survey, Indianapolis

## HYDROGEOLOGY OF THE GLACIAL DRIFT AQUIFER SYSTEM AT THE INDIANA DUNES NATIONAL LAKESHORE

Starting date: 10/1979

Completion date: 9/1986

Project no: IN 79-060

Sponsor: National Park Service

AREA: Indiana - south shore of Lake Michigan; Indiana Dunes  
National Lakeshore; Southern Lake Michigan

### KEYWORDS:

geology, groundwater, hydrology, sand dunes, glacial,  
aquifer, water quality, wetlands, pollution,  
chemistry, inorganics, nutrients, trace metals,  
organic carbon, sediment cores, model

### DESCRIPTION:

#### Problem:

The Indiana Dunes National Lakeshore, located along the southern shore of Lake Michigan, is surrounded by heavy industry, expanding urban areas and agricultural areas. As part of its management responsibilities, the National Park service is required to protect the hydrologic and chemical integrity of the groundwater system of the lakeshore from man's activities, including additions and withdrawals of groundwater from the unconsolidated deposits in the area. The lakeshore also contains considerable marshlands. Detailed knowledge of geohydrology and water quality of the lakeshore and surrounding areas is required for effective management by the Park Service.

#### Objective:

(1) Define the groundwater system in the unconsolidated deposits underlying the Lakeshore and surrounding area including establishing the hydraulic relation between the groundwater system and the marsh areas. (2) Define the general quality of the groundwater and investigate how it may have been affected by industrial, commercial, residential, and agricultural development.

#### Approach:

Observation wells will be drilled to define the geometry and horizontal and vertical flow patterns of the unconsolidated aquifer system. Rates and distribution of groundwater pumpage will be determined. The hydraulic relation between the marsh and the groundwater system will be established by installation of hand-driven observation wells,

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

operation of streamgaging stations, and by streamflow gain/loss measurements. A water-quality assessment will be made by sampling water from representative wells throughout the lakeshore, including the marsh areas. Water samples from selected wells will be analyzed for dissolved inorganic constituents, dissolved organic carbon, nutrients, and trace elements.

### Results:

Because of the many new cores, augered test holes, and geophysical logs in wells obtained in the field seasons of 1984 and 1985, our conceptual model of the geological layering in the study area was extensively revised resulting in twelve new hydrogeologic cross-sections. A digital cross-section model was constructed to represent the aquifer system in the Cowles and State Park Units of the Lakeshore. Regional and intermediate scale flow patterns consistent with the hydrochemical and potentiometric data were simulated in this model. Summary report submitted in summer 1986.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 283

SHERRILL, M.

Illinois - U.S. Geological Survey, Urbana

HYDROGEOLOGICAL INVENTORY AND ASSESSMENT OF THE  
GREAT LAKES BASIN

Starting date: 1/01/1987

Completion date: 12/31/1987

Project no: 441708100

Sponsor: U.S. Geological Survey; State Dept.

AREA: Lake Michigan; Lake Superior; Lake Huron; Lake Erie;  
Lake Ontario; tributaries; Great Lakes Basin

KEYWORDS:

geology, hydrology, groundwater, water quality,  
pollution, nonpoint source, contaminants, aquifer,  
land use, mapping, bibliography, review, database

DESCRIPTION:

This project will inventory, assess, and subsequently identify the major hydrogeologic regimes that have a high potential for contaminating the Great Lakes. A literature review is being undertaken to assess existing information on potential groundwater contamination into the Great Lakes, and a listing of ongoing groundwater projects and available data and maps is being compiled.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 284

SONZOGNI, W.C.

Wisconsin - University of Wisconsin-Madison  
Water Chemistry Program and  
State Laboratory of Hygiene

PERSPECTIVES ON RESEARCH ON CHEMICAL CONTAMINANTS  
IN THE GREAT LAKES

Starting date: 9/01/1983

Completion date: 8/31/1986

Project no:

Sponsor: NOAA - National Marine Pollution Program Office

AREA: Great Lakes

KEYWORDS:

chemistry, risk assessment, model, human health,  
toxics, organics, water quality, contaminants,  
human consumption, fish, management

DESCRIPTION:

Objectives:

- (1) Compare the likely hazards of selected toxic chemical contaminants at levels currently found in the Great Lakes.
- (2) Provide perspectives on risks posed by Great Lakes toxic chemical contaminants when compared with other common environmental risks.
- (3) Develop a framework useful for coordinating research on Great Lakes chemical contaminants.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 285

SONZOGNI, W.C.; DUBE, D.J.

Wisconsin - University of Wisconsin-Madison  
Water Chemistry Program and  
State Laboratory of Hygiene

## WORKSHOP ON METHODS FOR ANALYSIS OF ORGANIC COMPOUNDS IN THE GREAT LAKES, II

Starting date: 9/01/1985

Completion date: 10/31/1986

Project no: R/MW-34

Sponsor: University of Wisconsin Sea Grant Institute

AREA: Great Lakes

### KEYWORDS:

chemistry, analytical methods, contaminants, dioxins,  
furans, xenobiotics, toxics, organics, water quality

### DESCRIPTION:

#### Objectives:

To organize and host the second workshop on the analysis of organic compounds in the Great Lakes. The results of the workshop, which will focus on recent advances, problems and experiences in the Great Lakes ecosystem, will be summarized and disseminated.

#### Methodology:

A national workshop was held in Madison, Wisconsin, in October, 1985; proceedings to be published and distributed.

#### Rationale:

The problem of xenobiotic contaminants in the Great Lakes and other marine waters is exacerbated by the overall difficulty in measuring these contaminants. A workshop was held in 1980 to exchange information on analytical techniques. Since that first workshop, new analytical techniques and problems have emerged, creating the need for a second workshop.

#### Accomplishments:

A two-day workshop was held in October, 1985, in Madison, Wisconsin. Attendance: 70. Final chapters being written for U.W. Sea Grant Institute publication similar to the publication resulting from 1980 workshop for dissemination to workshop participants. Topics cover quality control in the laboratory as well as analysis of dioxins, furans, and capillary column chromatography in terms of identifying pollutants.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 286

STALLING, D.

Missouri - U.S. Fish and Wildlife Service, Columbia  
Columbia National Fisheries Research Lab

## NATIONAL CONTAMINANT BIOMONITORING PROGRAM

Starting date: 7/1977  
Completion date: Continuing  
Project no: Project 881  
Sponsor: U.S. Fish and Wildlife Service

AREA: Lake Michigan; Lake Superior; Lake Huron; Lake Ontario;  
Lake Erie; U.S. rivers

### KEYWORDS:

water quality, fish, biology, chemistry, DDT, PCBs, dioxins, toxaphene, chlordane, organics, toxics, analytical methods, pattern recognition, dibenzofurans, monitoring, river, inorganics, heavy metals, management, contaminants, lake trout, walleye, perch, pollution, organochlorine pesticides

### DESCRIPTION:

#### Objectives:

- (1) To monitor for trends in pesticides, heavy metals and other environmental contaminants in anadromous and freshwater fish collected from designated sampling sites in U.S. rivers and the Great Lakes. Fish are being analyzed for selected highly residual organochlorine and elemental contaminants. In the 3 upper Great Lakes, lake trout is the predator species sampled; in the 2 lower Great Lakes, coolwater species, such as walleye and perch, are collected.
- (2) To identify and assess new or previously undetected contaminants which may threaten the wellbeing of important fishery resources.
- (3) To provide technical assistance in the areas of analytical chemistry and applied toxicology to U.S.F.W.S. biologists and other federal and state agencies.
- (4) To make routine residue analyses more cost-effective and comprehensive through development and implementation of automated procedures and improve analytical methods.
- (5) To recommend management alternatives for dealing with pollution problems.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 287

STUBBLEFIELD, B.; BENNETT, J.R.  
Michigan - NOAA/GLERL, Ann Arbor

GREAT LAKES ICE DYNAMICS MODELING

Starting date:  
Completion date: 1984  
Project no: Task 8.13  
Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:  
model, physical, ice

DESCRIPTION:

The objective of this task is to develop Great Lakes ice dynamics models for simulation and forecasting.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 288

STYNES, D.J.

Michigan - Michigan State University, East Lansing  
Parks and Recreation Dept.

## RECREATION AND TOURISM FORECASTING

Starting date: 7/01/1987

Completion date: 6/30/1989

Project no: R/CE-01

Sponsor: Michigan Sea Grant College Program

AREA: Michigan coastal counties along Lake Michigan, Lake Superior, Lake Huron, Lake Erie

### KEYWORDS:

recreation, tourism, economics, model

### DESCRIPTION:

#### Objectives:

1. Evaluate suitability of secondary economic data series for recreation and tourism forecasting.
2. Test and compare alternative forecasting models on selected series.
3. Test procedures for isolating tourism components of available economic data series.
4. Develop and test forecasting models based upon multiple time series.
5. Identify variations in trends and seasonal patterns of recreation and tourism activity in the coastal zone.

#### Methodology:

We will compare and evaluate several alternative forecasting models on secondary time series data for coastal counties in Michigan. The suitability of different data series will be evaluated and systems for tracking tourism activity and forecasting likely futures will be developed from several data series. Time series and structural methods will be compared and combined time series/structural models will be estimated and evaluated. Time series data on use, sales, taxes, employment and other tourism-related measures will be used. Data series available on a monthly or quarterly basis at the county or regional level will be used for the period 1974-1985.

#### Rationale:

Improved tourism tracking and forecasting procedures are needed for tourism organizations to identify trends and likely futures on which to base development and marketing decisions. Methods for isolating tourism components of available data series will reduce data collection costs.



# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 289

SULLIVAN, J.

Wisconsin - Wisconsin Dept. of Natural Resources, Madison

## TOXIC MONITORING PROGRAM FOR THE LOWER FOX RIVER

Starting date:

Completion date: Continuing

Project no: WI-102

Sponsor: Wisconsin Dept. of Natural Resources

AREA: Fox River; Green Bay; Wisconsin; Lake Michigan

### KEYWORDS:

chemistry, biology, toxics, contaminants, organics, fish, water quality, sediments, clams, fate, PCBs, discharge, loading, bioaccumulation, river, monitoring

### DESCRIPTION:

The subject of toxic pollutants contained in fish tissue, water, and sediment of the Lower Fox River from the Lake Winnebago outlet into lower Green Bay continues to be of great concern to the general public, the DNR, and federal agencies. A study plan consisting of trend analysis, an intensive sediment survey, and a clam study has been developed to monitor toxic pollutants. The trend analysis component consists of a long-term monitoring program to track the fate of toxic pollutants in the Lower Fox River and Green Bay. The purpose of the sediment survey is to more precisely locate and quantify the extent of PCB-containing sediments in four general areas of the Fox River. Previous sampling has indicated that the PCB content in these areas is much higher than in most other locations in the river, owing to sediment deposition or the proximity to known PCB discharges. The objectives of the clam studies are to perform bioaccumulation studies using a filter-feeding organism that is known to accumulate PCB's rapidly, and to determine if the discharge is continuing to cause PCB loading to the river system.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 290

TALHELM, D.R.

Michigan - Michigan State University, East Lansing  
Department of Biology

SOCIAL ASSESSMENT OF FISHERY RESOURCES

Starting date:

Completion date:

Project no:

Sponsor: Sponsor Not Known

AREA: Lake Michigan; Lake Ontario; Lake Huron; Lake Erie; Lake  
Superior

KEYWORDS:

biology, fish, lake trout, management, economics

DESCRIPTION:

The project is a symposium on the social assessment  
of fishery resources.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 291

TARAPCHAK, S. J.

Michigan - NOAA/GLERL, Ann Arbor

PHOSPHORUS CYCLING IN THE LAKE MICHIGAN MICROBIAL  
FOOD WEB: PHYTOPLANKTON-BACTERIAL COMPETITION

Starting date: 1984

Completion date: 1986

Project no: Task 6.42

Sponsor: NOAA

AREA: Lake Michigan

KEYWORDS:

biology, phytoplankton, bacteria, heterotrophy,  
microbiology, food chain, cycling, nutrients,  
phosphorus, inorganics, chemistry, botany

DESCRIPTION:

The objective of this task is to determine  
if heterotrophic bacterioplankton compete with  
phototrophic phytoplankton for dissolved inorganic  
phosphorus in lake waters.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 292

TARAPCHAK, S.J.

Michigan - NOAA/GLERL, Ann Arbor

PHOSPHORUS-PHYTOPLANKTON DYNAMICS IN LAKE MICHIGAN

Starting date:

Completion date: 1986

Project no: Task 6.30

Sponsor: NOAA

AREA: Lake Michigan

KEYWORDS:

biology, chemistry, silica, phosphorus, cycling,  
phytoplankton, nutrients, growth, botany, inorganics

DESCRIPTION:

The objective of this task is to evaluate the role of secondary limitation of algal growth by silica on phosphorus cycling in the epilimnion of an offshore station in Lake Michigan.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 293

TARAPCHAK, S.J.; HERCHE, L.  
Michigan - NOAA/GLERL, Ann Arbor

PHOSPHATE UPTAKE AND PHYTOPLANKTON GROWTH RATES  
IN SOUTHERN LAKE MICHIGAN

Starting date:  
Completion date: Continuing  
Project no: Task 5.10  
Sponsor: NOAA

AREA: Southern Lake Michigan

KEYWORDS:

model, biology, phytoplankton, nutrients, phosphorus,  
growth, physiology, succession, competition, uptake,  
botany, inorganics, chemistry

DESCRIPTION:

Objectives:

- (1) To investigate the relationships among, and the underlying physiologic causes of, variations in orthophosphate uptake and phytoplankton growth rates in southern Lake Michigan.
- (2) To (a) provide physiological data for interpreting patterns in phytoplankton succession and phytoplankton nutrient competition, and (b) to test mathematical constructs describing phosphorus-limited phytoplankton growth in whole-lake ecosystem models.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 294

TARAPCHAK, S.J.; VANDER PLOEG, H.A.  
Michigan - NOAA/GLERL, Ann Arbor

ANALYSIS OF GROWTH RATES OF PHYTOPLANKTON SPECIES  
IN SOUTHERN LAKE MICHIGAN

Starting date:  
Completion date: Continuing  
Project no: Task 5.11  
Sponsor: NOAA

AREA: Southern Lake Michigan

KEYWORDS:

biology, phytoplankton, growth, populations, botany,  
photosynthesis, silica, inorganics, phosphorus,  
blue-green algae, nutrients, succession, competition,  
zooplankton grazing, sinking rates

DESCRIPTION:

Objectives:

- (1) Document the seasonal succession pattern of algae in Lake Michigan and describe the significance of nutrient competition, algal sinking, and zooplankton grazing on this succession.
- (2) Test the Schelske-Stoermer (1972) hypothesis that has been advanced to explain the development of blue-green algal populations in Lake Michigan.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 295

TAYLOR, R.; CHERKAUER, D.; ANDERSON, M.  
Wisconsin - University of Wisconsin-Milwaukee  
Geological and Geophysical Sciences Dept.  
Wisconsin - University of Wisconsin-Madison  
Geology and Geophysics Dept.

## MEASUREMENT OF THE INTERACTION BETWEEN LAKE MICHIGAN AND THE GROUNDWATER OF WISCONSIN

Starting date: 9/01/1984  
Completion date: 8/31/1989  
Project no: R/MW-35  
Sponsor: University of Wisconsin Sea Grant Institute

AREA: Wisconsin waters; Western Lake Michigan; Green Bay; Door  
County

### KEYWORDS:

geology, geophysical, hydrology, electrical resistivity,  
seismic surveys, porosity, permeability, sediments,  
aquifer, groundwater, water budget, model, mapping

### DESCRIPTION:

#### Objectives:

To: (1) produce quantitative maps of the hydraulic conductivity of Lake Michigan bottom sediments along the the entire Lake Michigan/Wisconsin shoreline; (2) field verify the accuracy of these maps at selected shoreline sites; (3) combine the offshore studies with the onshore studies to produce quantitative maps of the Lake Michigan-Wisconsin groundwater interaction; (4) quantify the role of groundwater in Western Lake Michigan water budgets.

#### Methodology:

Combine marine seismic results with electrical longitudinal conductance and induced polarization; use a computer automated marine geophysical system from a previous Sea Grant project; use numerical modeling of lake water/groundwater interactions.

#### Rationale:

A quantitative measure of the potential for lake/groundwater interaction is necessary to plan the development of shoreline aquifers and waste disposal sites, assess the impact of lake water export and define potential changes in lake water pollution levels. This project will quantify the role of groundwater in western Lake Michigan's budget.

#### Accomplishments:

Field work concentrated on the Green Bay side of Door County and Door County itself. Seepage meters were emplaced in Green Bay to obtain direct measurements of seepage to the

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Bay. Groundwater levels were monitored in wells along a series of cross sections through Door County. Geophysical surveys were conducted along several lines in Green Bay. All of these data will be synthesized with the aid of a groundwater flow model of Door County and the nearshore area of Green Bay to allow an estimate of the flux of groundwater to the Bay.

### Benefits:

Regional planning commissions, regulatory agencies and government units will use this information to assess the effects of aquifer development or waste disposal programs on Lake Michigan, as will committees assessing the impact of Lake Michigan water export and fish studies involving fish whose behavior is determined in part by the presence of lake bottom springs.



# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 296

TAYLOR, W.

Michigan - Michigan State University, East Lansing  
Dept. of Fisheries and Wildlife

## COMPARATIVE ANALYSIS OF YEAR-CLASS STRENGTH AND POPULATION PARAMETERS OF PINK SALMON IN THE UPPER GREAT LAKES

Starting date: 7/01/1987

Completion date: 6/30/1991

Project no: R/GLF-32

Sponsor: Michigan Sea Grant College Program

AREA: Michigan tributaries for Lake Michigan, Lake Superior,  
Lake Huron, and Lake Erie

### KEYWORDS:

biology, fish, pink salmon, recruitment, spawning,  
tributaries, flow, populations, model, habitat,  
water quality, hydrology, groundwater, year-class  
strength, life history, abundance, fish eggs

### DESCRIPTION:

#### Objectives:

1. Develop statistical models of stream flow for all major pink salmon spawning streams in Michigan waters of the Upper Great Lakes in order to identify and evaluate groundwater and surface water controlled tributaries.
2. Develop Habitat Suitability Index curves for spawning pink salmon, incubating eggs, and alevins in order to identify habitat quality for these life history stages.
3. Develop Instream Flow Incremental Methodology models for selected groundwater and surface controlled streams in order to quantify the amount of available spawning and incubation habitat under various flow conditions and their relationship to redd superimposition and stream bed overseeding.
4. Determine the population characteristics and abundance of spawning pink salmon and their progeny in these streams.
5. Develop a predictive model of year-class strength and recruitment based on the integration of the evaluated biotic and abiotic factors.

#### Methodology:

Adult salmon will be collected in selected groundwater and surface water controlled streams using electrofishing techniques. Up to 500 will be sampled, fin clipped, measured, and released to provide estimates of size, sex ratio, and abundance.

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

### Rationale:

The biology and population dynamics of Great Lakes pink salmon is inadequately understood. To properly manage this fish an understanding of their dynamics and yield potential is essential. This research will provide this information and allow for efficient management of this species.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 297

TAYLOR, W.; KEVERN, N.

Michigan - Michigan State University, East Lansing  
Dept. of Fisheries and Wildlife

## FACTORS CONTROLLING RECRUITMENT AND YEAR-CLASS VARIABILITY OF LAKE WHITEFISH (COREGONUS CLUPEAFORMIS)

Starting date: 2/01/1985

Completion date: 1/31/1989

Project no: R/GLF-19

Sponsor: Michigan Sea Grant College Program

AREA: Northern Lake Michigan; Grand Traverse Bay

### KEYWORDS:

whitefish, fish, biology, growth, larval fish,  
temperature, currents, fish eggs, zooplankton,  
diet, survival, recruitment, abundance, model,  
year-class strength, commercial fishing,  
management, populations, life history

### DESCRIPTION:

#### Objectives:

Laboratory and field studies directed at determining larval lake whitefish growth and survival as functions of egg quality, amount of food (zooplankton) per larvae at hatching, water temperature and current speeds will be undertaken over a four-year period. It is hypothesized from previous studies that year-class strength, and thus recruitment, is significantly influenced by these four variables. Specifically, in selected areas of northern Lake Michigan, the following will be determined:

- 1) quality and quantity of egg drop, 2) larval fish abundance, 3) zooplankton abundance at whitefish hatch and subsequent two months when these larvae are inshore and feeding on zooplankton. In the laboratory the following relationships will be determined under varying food rations, water temperatures and current speeds:
    - 1) egg quality to growth and survival of whitefish larvae;
    - 2) food abundance to growth and survival of whitefish larvae.
- A model using this data will be developed which predicts year-class strength and future recruitment to the fishery.

#### Rationale:

At present, there is no reliable, valid method for forecasting year-class strength and recruitment to lake whitefish stocks. The success and stability of most Lake Michigan commercial fisheries is very dependent on a small number of whitefish year classes, which fluctuate widely and unpredictably from year to year. Fishermen

## LAKE MICHIGAN PROJECTS - 1984-CONTINUING

cannot plan or anticipate catch in any future year and managers cannot set advance harvest or gear restrictions without knowledge of expected recruitment. The goal of this project is to develop a valid method for predicting variability in recruitment.

### Accomplishments:

To date, this study has concluded that stock size, overwinter egg survival, and food per larval fish ratios are important factors controlling year-class strength. Modeling efforts based on these factors indicate increased reliability in recruitment predictions as compared to the traditional stock-recruitment relationship. One thesis has been completed, another is in review, various presentations have been given, and two papers have been published.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 298

THOMANN, R.; DITORO, D.

New York - Manhattan College, Bronx

Environmental Engineering and Science

PHYSICO-CHEMICAL MODEL OF TOXIC SUBSTANCES  
IN THE GREAT LAKES

Starting date:

Completion date: 1984

Project no:

Sponsor: U.S. EPA - Duluth

AREA: Great Lakes; Lake Michigan

KEYWORDS:

model, chemistry, physical, toxics, organics, fate,  
particulates, sediments, atmospheric, radionuclides,  
resuspension, transport, inorganics, PCBs,  
sediment-water interface, air-water interface,  
diffusion, benzo-a-pyrene, sorption, desorption  
cadmium, trace metals, volatilization, PAHs,  
partition coefficients

DESCRIPTION:

A physico-chemical model of the fate of toxic substances in the Great Lakes was constructed from mass balance principles and incorporating principal mechanisms of particulate sorption-desorption, sediment-water and air-water interactions, and chemical and biochemical decay. Calibration of the toxic model is through comparison of plutonium-239 data.

The calibrated model was applied to the PCBs in Lake Michigan and the importance of solids-dependent partition coefficients and resulting sediment diffusion was explored. Finally, application of the model was made to benzo-a-pyrene and cadmium in the Great Lakes.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 299

TISUE, G.T.

South Carolina - Clemson University, Clemson  
Chemistry Dept.

X-RAY FLUORESCENCE ANALYSES OF FILTERS FROM A  
CONTINUOUS SAMPLER AT INDIANA SHOALS TOWER

Starting date: 12/15/1984

Completion date: 8/15/1986

Project no:

Sponsor: U.S. EPA - Great Lakes National Program Office

AREA: Southern Lake Michigan and air shed

KEYWORDS:

chemistry, atmospheric transport, sampling, trace metals,  
x-ray fluorescence, meteorology, inorganics

DESCRIPTION:

Twelve months of daily (continuously collected)  
air filters from the Indiana Shoals Tower from  
1979-1980 were analyzed by x-ray fluorescence analysis  
for 14 trace metals. Interpretation of the data is  
based on simultaneous meteorological data and comparison  
with crib-based samplers. One M.S. thesis has been  
completed from this work.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 300

TISUE, G.T.

South Carolina - Clemson University, Clemson  
Chemistry Dept.

BENTHIC BOUNDARY LAYER SAMPLING SYSTEM DEVELOPMENT

Starting date:

Completion date: Continuing

Project no:

Sponsor: NOAA/GLERL (ship time); South Carolina Sea Grant  
Consortium

AREA: Great Lakes; Laboratory

KEYWORDS:

physical, benthic boundary layer, sampling, water quality,  
chemistry, sediment-water interface, particulates

DESCRIPTION:

Automated sampler used to investigate particle  
and solute gradients at the sediment-water interface.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 301

TISUE, G.T.

South Carolina - Clemson University, Clemson  
Chemistry Dept.

SEASONAL ZINC CYCLING IN EPILIMNETIC WATERS

Starting date:

Completion date: Continuing

Project no:

Sponsor: Sponsor Not Known

AREA: Southern Lake Michigan

KEYWORDS:

inorganics, zinc, trace metals, cycling, transport,  
chemistry, mixing, resuspension, calcium carbonate,  
water quality, atmospheric deposition, particulates,  
model, stratification

DESCRIPTION:

Objective:

To measure zinc concentrations in the offshore waters of Lake Michigan and determine factors affecting the observed concentration patterns; these factors will be used to develop a model for the behavior of zinc in large freshwater lakes.

Results:

Measurements were made of zinc in the offshore waters of Lake Michigan's southern basin. Spatial and temporal variations in the element's concentrations are pronounced, and are characterized by strong seasonal dependence. These variations are driven in part by a large atmospheric source term in the offshore waters, as indicated by an increase in epilimnetic concentrations during late stratification (mean of 1270 ng/l, vs. 690 ng/l in early spring). Another important factor is the strong removal of zinc from the epilimnion associated with carbonate precipitation. The effects of isothermal remixing and resuspension also are discernible. These phenomena are accomplished by marked changes in the partitioning of zinc between soluble/collodial and particulate species.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 302

TISUE, G.T.

South Carolina - Clemson University, Clemson  
Chemistry Dept.

USE OF THE FALLOUT RADIONUCLIDE  $^{113}\text{m}\text{-Cd}$  AS A  
BIOGEOCHEMICAL TRACER

Starting date:

Completion date: Continuing

Project no:

Sponsor: Sponsor Not Known

AREA: Southern Lake Michigan

KEYWORDS:

tracer, transport, water quality, atmospheric, model,  
chemistry, trace metals, cadmium, radionuclides,  
sediments, mass balance, inorganics, geochemistry

DESCRIPTION:

The existence of isotopic tracers proved crucial in unravelling the behavior of, e.g., lead, plutonium, and cesium in the Great Lakes. This list can now be extended to include cadmium, based on the use of cadmium- $^{113}\text{m}$  (half-life = 14.6 y). Although most cadmium- $^{113}\text{m}$  entered the environment over two decades ago, we have developed methods for determining it in Lake Michigan water and sediment. The source term was estimated by analyzing undisturbed soils from the watershed. These data provide a means of validating mass balance models for cadmium independent of measurements of the stable isotopes.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 303

U.S. EPA

Michigan - Large Lakes Research Station, Grosse Ile

CONTAMINANTS IN GREEN BAY FISH

Starting date: 1987

Completion date: 1989

Project no:

Sponsor: U.S. EPA - Great Lakes National Program Office

AREA: Green Bay; Wisconsin waters; Lake Michigan

KEYWORDS:

biology, chemistry, contaminants, toxics, fish

DESCRIPTION:

Ref. no. 304

U.S. EPA - REGION V

GRAND CALUMET WASTE LOAD ALLOCATION MODEL  
AND RISK ASSESSMENT

Starting date: 1985

Completion date: 1985

Project no:

Sponsor: U.S. EPA - Great Lakes National Program Office

AREA: Grand Calumet River; Indiana Harbor Canal; Southern Lake  
Michigan

KEYWORDS:

chemistry, loading, risk assessment, model, sediments,  
pollution, waste disposal, discharge, water quality,  
river, harbors, organics

DESCRIPTION:

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 305

VANDERPLOEG, H.A.; BOLSENGA, S.J.; FAHNENSTIEL, G.L.;  
GARDNER, W.S.

Michigan - NOAA/GLERL, Ann Arbor

WINTER ECOLOGY

Starting date: 1987  
Completion date: Continuing  
Project no: Task 6.49  
Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

biology, winter, ice, temperature, invertebrates,  
zooplankton, phytoplankton, populations, benthic

DESCRIPTION:

This project is gathering data on the state of  
the biota under the ice.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 306

VANDERPLOEG, H.A.; GARDNER, W.S.; FAHNENSTIEL, G.L.;  
LIEBIG, J.R.

Michigan - NOAA/GLERL, Ann Arbor

ECOLOGY OF AN INVADER: THE PHYSIOLOGICAL ECOLOGY  
OF BYTHOTREPHES AND ITS EFFECT ON FOOD WEB STRUCTURE  
IN THE GREAT LAKES

Starting date: 1987  
Completion date: Continuing  
Project no: Task 5.31  
Sponsor: NOAA

AREA: Great Lakes

KEYWORDS:

biology, phytoplankton, zooplankton, invertebrates,  
food chain, nutrients, inorganics, cycling, diet,  
physiology, Cladocera

DESCRIPTION:

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 307

VANDER PLOEG, H.A.; TARAPCHAK, S.J.  
Michigan - NOAA/GLERL, Ann Arbor

ZOOPLANKTON GRAZING

Starting date:  
Completion date: 1985  
Project no: Task 5.2  
Sponsor: NOAA

AREA: Lake Michigan; Laboratory

KEYWORDS:

biology, zooplankton, grazing, Copepoda, diet,  
temperature, phytoplankton, Diaptomus, feeding

DESCRIPTION:

Objectives:

- (1) To determine seasonal size-selective grazing rates by females of the four different species of Diaptomus found in Lake Michigan. Correlate food size selection and morphology of the filtering apparatus. Relate feeding rates to environmental parameters, such as kinds of algae available as food and temperature.
- (2) To try out potentially promising narcotizing agents for use as zooplankton-specific killing agents for in situ studies of grazing, using the Gliwicz method (1968) automated by the use of the Coulter Counter.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 308

WANG, W.

Illinois - Illinois State Water Survey, Champaign

PHYTOTOXICITY OF WAUKEGAN HARBOR USING PHYTOASSAY METHODS

Starting date: 1986

Completion date: 1987

Project no: 020

Sponsor: University of Illinois Hazardous Waste Res. and  
Info. Center

AREA: Waukegan Harbor; Lake Michigan; Laboratory

KEYWORDS:

biology, bioassay, chemistry, sediments, toxics, PCBs,  
organics, vegetation, duckweed, millet, contaminants,  
reproduction, growth, botany

DESCRIPTION:

The purpose of this project is to assess the toxicity potential of contaminated sediment samples using tests on plants. Bottom sediment is generally considered a sink for environmental pollutants. However, various natural or artificial actions can cause sediment to resuspend and transport and thus create secondary pollution effects. Sediments are also active biological zones and can be an important component of an ecosystem. In this study, sediments from Waukegan Harbor, contaminated to various levels with PCBs, will be investigated in the form of a slurry using the duckweed reproduction test and the millet root elongation test. The results of these phytoassay tests will be compared with results of other tests using bacteria, algae, and nematodes. This information will be used to assess the accuracy of the direct phytoassay methods in determining sediment toxicity.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 309

WEBER, W.J., JR.

Michigan - University of Michigan, Ann Arbor  
Civil Engineering Dept.

## THE EFFECTS OF DISSOLVED ORGANIC MATTER ON THE BIOAVAILABILITY OF CHLORINATED HYDROCARBONS (CH'S)

Starting date: 2/01/1986

Completion date: 1/31/1987

Project no: R/TS-29

Sponsor: Michigan Sea Grant College Program

AREA: Laboratory

### KEYWORDS:

organics, analytical methods, bioavailability, uptake, chemistry, biology, bioaccumulation, PAHs, organic carbon, humic acid, toxics, water quality, model, phytoplankton, organic matter

### DESCRIPTION:

#### Objectives:

- 1) Design a methodology to directly apply Reverse Phase High Performance Liquid Chromatography (RPHPLC) for predicting the bioavailability and bioaccumulation of chlorinated hydrocarbons to aquatic organisms.
- 2) Characterize the effects of background dissolved organic matter on chlorinated hydrocarbon (CH) bioavailability and bioaccumulation.
- 3) Develop models to quantify and predict these phenomena.
- 4) Calibrate and verify the model to field studies.

#### Methodology:

The RPHPLC retention times of six CH's will be corrected to bioconcentration factors (BCF's) and data from planktonic uptake studies in the presence of varying amounts of natural DOC from surface waters in Michigan and a commercially available DOC, Aldrich Humic Acid.

#### Rationale:

The results from this study will be of direct and immediate benefit to individuals and institutions concerned with the toxic effects of CH's on aquatic organisms. In addition, the methodologies and models developed from the project will facilitate rapid and accurate measurements by state, local, and federal agencies.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 310

WELLS, L.

Michigan - National Fisheries Center - Great Lakes, Ann Arbor

SURVEILLANCE AND STATUS OF FISH POPULATIONS -- LAKE MICHIGAN

Starting date: 1/1970

Completion date: Continuing

Project no:

Sponsor: U.S. Fish and Wildlife Service

AREA: Lake Michigan

KEYWORDS:

fish, biology, bloater chub, alewife, yellow perch, smelt, deepwater sculpin, slimy sculpin, salmonid, monitoring, populations, mortality, reproduction, growth, diet, lake trout, chub, whitefish, management, distribution, abundance, sea lamprey

DESCRIPTION:

Regular, systematic sampling each year with trawls, gillnets, tow nets and other gear yields detailed information on abundance, distribution, size/age composition, growth, mortality, maturity, and diet for Lake Michigan lake trout, chub, whitefish, yellow perch, and preyfish resources, as well as data on degree of success of sea lamprey control and lake trout rehabilitation programs. This critical information forms the basis for research by U.S.F.W.S. in cooperation with other agencies to (1) determine the status of the stocks; (2) evaluate the impact of the fisheries; (3) develop new interagency management plans; (4) predict total allowable catch of chub, lake trout, and whitefish in treaty-ceded waters; (5) determine capacity of prey-fish stocks to sustain present or increased levels of salmonid predation.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 311

WESELOH, D.V.; STRUGER, J.R.

Ontario - Canadian Center for Inland Waters, Burlington  
Canadian Wildlife Service

## ORGANOCHLORINE CONTAMINANTS AND MERCURY IN HERRING GULL EGGS FROM THE GREAT LAKES, 1983-84

Starting date: 1980  
Completion date: Continuing  
Project no:  
Sponsor: Canadian Wildlife Service

AREA: Lake Michigan; Lake Superior; Lake Huron; Lake Erie;  
Lake Ontario; Green Bay

### KEYWORDS:

biology, chemistry, toxics, contaminants, organics,  
DDE, DDT, mirex, PCBs, herring gulls, birds, eggs,  
dieldrin, monitoring, mercury, inorganics, chlordane,  
endrin, chlorobenzenes, metals, heptachlor epoxide,  
organochlorine pesticides

### DESCRIPTION:

From 1974 to 1979 levels of toxic chemicals (DDE, DDT, HCB, mirex, and PCBs) in Herring Gull eggs from the Great Lakes decreased dramatically. From 1979/1980 to 1982 however, levels of most of these compounds as well as levels of dieldrin increased (some significantly) at several sampling sites throughout the Great Lakes. From 1982 to 1983 the situation again changed and there was a sharp decrease (often significantly) in the levels of all 6 compounds.

In 1983-84, herring gull eggs from 13 colony sites from throughout the 5 Great Lakes and connecting channels were analyzed for 18 organic contaminants and mercury. Sixteen of the compounds showed highly significant ( $P < 0.001$ ) variation in concentrations among sites. The highest levels of eight different compounds: DDE, dieldrin, heptachlor epoxide, DDT, alpha-chlordane, oxychlordane, endrin, and beta-HCH, occurred in gull eggs at Big Sister Island, Green Bay, Lake Michigan. The highest levels of tetra- and penta-chlorobenzene were found in eggs from Saginaw Bay, Lake Huron. PCBs and HCB were greatest in eggs from Fighting Island, Detroit River. Colonies on Lake Ontario had the highest levels of mirex, beta-HCH, and mercury.

Between 1983 and 1984 levels of all compounds except dieldrin, mirex, and gamma-chlordane significantly decreased on at least one colony site. Thirteen compounds decreased significantly in eggs from Granite Island in Lake Superior.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 312

WESELOH, D.V.; STRUGER, J.R.; KUBIAK, T.J.

Ontario - Canadian Center for Inland Waters, Burlington  
Canadian Wildlife Service;

Ontario - Canadian Center for Inland Waters, Burlington  
Canadian Wildlife Service;

Wisconsin - U.S. Fish and Wildlife Service, Green Bay

THE OCCURENCE OF CONGENITAL ANOMALIES IN DOUBLE-CRESTED  
CORMORANTS AND HERRING GULLS IN THE GREAT LAKES

Starting date:

Completion date: Continuing

Project no:

Sponsor: Canadian Wildlife Service; U.S. Fish and Wildlife  
Service

AREA: Great Lakes; Green Bay; Door County; Lake Michigan

KEYWORDS:

biology, cormorants, birds, herring gulls, chemistry,  
toxics, contaminants, deformity, physiology, organics

DESCRIPTION:

In 1983 and/or 1984, approximately 1700 Herring Gull chicks from four colonies and 8300 young Double-crested Cormorants from 33 colonies were examined for congenital anomalies on the Great Lakes. No anomalies were found in Herring Gull chicks but 36 cormorants with anomalies were found: deformed bills and deformed eyes. The former were located primarily in the Green Bay /Door County Peninsula area of Lake Michigan, Wisconsin and the latter from eastern Lake Ontario near Kingston, Ontario. The incidence of anomalies ranged from zero on Lakes Erie, Superior, and Lake-of-the-Woods (0 of 2265) to 0.95% or (31 of 3249) from Lake Michigan. This is the first time in 10 years that the widespread occurrence of congenital anomalies in fish-eating birds on the Great Lakes have been found. At present, we do not know the cause of the deformities but toxic chemicals are suspected.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 313

WESELY, M.

Illinois - Argonne National Laboratory, Argonne  
Environmental Research Division

AIR-WATER PHYSICAL TRANSFER COEFFICIENTS  
IN OPEN LAKE CONDITIONS

Starting date:

Completion date: Continuing

Project no:

Sponsor: Sponsor Not Known

AREA: Lake Michigan

KEYWORDS:

chemistry, atmospheric, air-water interface,  
transport, loading, deposition, toxics, contaminants

DESCRIPTION:

Observations were made from a NOAA data buoy located in the southern basin of Lake Michigan to compute that the gas-phase, monthly average, transfer coefficients at a height of 10 m range from over 0.65 cm/s in March to about 0.2 cm/s in May, which are substantially lower than previous estimates. For a substance with a Schmidt number of 1500 in water, the aqueous physical transfer velocity varies from  $1.2 \times 0.001$  cm/s in March to  $0.4 \times 0.001$  cm/s in June. Calculations generally show that for substances with Henry's Law constants larger than about 2 Pa cubic meters/mole, the aqueous resistance to transfer is larger than the aerodynamic resistance near the surface. Computations for midlake conditions are necessary to evaluate the processes of dry deposition of toxic contaminants in the Great Lakes.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 314

WHITE, D.S.

Michigan - University of Michigan, Ann Arbor

REDISTRIBUTION OF SEDIMENT-BOUND TOXIC ORGANICS  
BY BENTHIC INVERTEBRATES

Starting date:

Completion date: Continuing

Project no:

Sponsor: NOAA

AREA: Southern Lake Michigan

KEYWORDS:

benthic, invertebrates, biology, sediments, toxics,  
organics, oligochaetes, feeding, mixing, bioturbation,  
pesticides, bioassay, water quality

DESCRIPTION:

The objective of this project is to measure the  
effect of chronic exposure of trace organic contaminants  
on sediment reworking rates of benthic invertebrates.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 315

WISCONSIN DEPT. OF NAT. RESOURCES

Wisconsin - Wisconsin Dept. of Natural Resources, Madison  
Bureau of Fish Management

STOCK RAINBOW TROUT STRAINS AND EVALUATE

Starting date:

Completion date: 1985

Project no:

Sponsor: Wisconsin Dept. of Natural Resources

AREA: Lake Michigan; Oconto River

KEYWORDS:

biology, fish, management, stocking, sport fishing,  
rainbow trout, tributaries, fish strains

DESCRIPTION:

This project will stock Shasta, Pikes Creek, and Skamania rainbow trout in the Oconto River and evaluate their return to anglers. The strains will be floy tagged prior to stocking. Tags will be returned via the Lake Michigan creel census, voluntary returns, assessment fishing, and electrofishing surveys. This project will identify which of these three strains are most suitable for stocking into Lake Michigan.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 316

WISCONSIN DEPT. OF NAT. RESOURCES

Wisconsin - Wisconsin Dept. of Natural Resources, Madison  
Bureau of Fish Management

STOCK BROOK TROUT STRAINS AND EVALUATE

Starting date:

Completion date: 1986

Project no:

Sponsor: Wisconsin Dept. of Natural Resources

AREA: Lake Michigan

KEYWORDS:

biology, stocking, management, brook trout, fish,  
fish strains, survival, growth, diet, distribution,  
movement, sport fishing, habitat

DESCRIPTION:

This project will stock 15,000 wild Nipigon and 15,000 domestic strain brook trout in Lake Michigan and will compare their survival to harvest. Each strain will be given an identifying marker prior to stocking. Growth, survival, food, habitats, distribution, movement, and angler catch will be monitored for each strain through 1986. This study will identify the best brook trout for stocking in Lake Michigan.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 317

WISCONSIN DEPT. OF NAT. RESOURCES

Wisconsin - Wisconsin Dept. of Natural Resources, Madison  
Bureau of Fish Management

COHO SALMON BROODSTOCK SELECTION

Starting date: 1984

Completion date: 1987

Project no:

Sponsor: Wisconsin Dept. of Natural Resources

AREA: Lake Michigan; Sheboygan River; Wisconsin

KEYWORDS:

biology, fish, coho salmon, fish eggs, spawning,  
fish strains, river

DESCRIPTION:

This project will collect fertilized coho salmon eggs and determine spawning run timing in the Sheboygan River. In addition, this project will obtain milt from early running coho populations in Alaska to hybridize with Lake Michigan coho eggs. The development of coho salmon strains that return to stocking locations in late August and September will enhance harvest of these fish. Currently, coho salmon return to Wisconsin streams in late October and November when angling activities are minimal. Assessment activities will compare timing of spawning between pure Lake Michigan and Lake Michigan-Alaska hybrid strains. The hybrid strains will be produced for three years. This operations activity will provide one million fertilized coho salmon eggs for hatching and rearing at the Kettle Moraine Springs and Lake Mills hatcheries.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 318

WISCONSIN DEPT. OF NAT. RESOURCES

Wisconsin - Wisconsin Dept. of Natural Resources, Madison  
Bureau of Fish Management

CHINOOK SALMON STOCKING EVALUATION

Starting date: 1982

Completion date: 1988

Project no:

Sponsor: Wisconsin Dept. of Natural Resources

AREA: Lake Michigan

KEYWORDS:

biology, management, fish, chinook salmon,  
stocking, distribution, age, growth, salmonid,  
survival, sport fishing

DESCRIPTION:

This project will stock 80,000 coded wire tagged chinook salmon each year 1982-1984. One lot of 20,000 uniquely marked salmon will be stocked each year at Marinette, Strawberry Creek, Sheboygan, and Racine. Tag returns are expected through 1987 with project completion in 1988.

The project will identify stocking locations that maximize the survival to harvest of stocked chinook salmon in Lake Michigan. In addition, the age composition, growth patterns, and catch distribution (seasonal and geographical) will be described. Coded wire tags will be implanted into fingerlings salmon at the Wild Rose Hatchery. Tags will be returned through the regular contact creel census and voluntary returns through the Great Lakes sport fishing clubs. Chinook salmon comprise 40% of the total Lake Michigan salmonid sport catch.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 319

WISCONSIN DEPT. OF NAT. RESOURCES

Wisconsin - Wisconsin Dept. of Natural Resources, Madison  
Bureau of Fish Management

LAKE MICHIGAN FISHERIES ASSESSMENTS

Starting date:

Completion date: Continuing

Project no:

Sponsor: Wisconsin Dept. of Natural Resources

AREA: Lake Michigan; Green Bay

KEYWORDS:

biology, management, fish, populations, growth,  
whitefish, yellow perch, smallmouth bass, walleye,  
northern pike, muskellunge, chub, age, distribution,  
movement, spawning, abundance, sport fishing,  
commercial fishing, regulation, mortality

DESCRIPTION:

This project encompasses assessments of populations of lake whitefish and Menominee whitefish, chub, yellow perch, smallmouth bass, walleye, northern pike, and muskellunge. Biological data will be collected by test gill nets, fyke nets, trawling, electrofishing, commercial catch reporting, and contract commercial fishing for the various species. Tagging studies will be implemented on whitefish to provide estimates of mortality. Studies will also evaluate perch catches from modified entrapment gear. Data collected will be used to determine harvest quota for the commercial chub fishery and data on walleye populations in Green Bay will be used to set biologically sound commercial and sport regulations.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 320

WISCONSIN DEPT. OF NAT. RESOURCES

Wisconsin - Wisconsin Dept. of Natural Resources, Madison  
Bureau of Fish Management

STOCK SPLAKE AND EVALUATE

Starting date:

Completion date: Continuing

Project no:

Sponsor: Wisconsin Dept. of Natural Resources

AREA: Lake Michigan; Green Bay; Marinette

KEYWORDS:

management, fish, stocking, splake, genetics,  
fish strains, sport fishing, lake trout, brook trout

DESCRIPTION:

This project will stock four lots of 10,000 splake in Green Bay near Marinette. Two lots of yearlings and fingerlings will be planted. F1 crosses will be made using female Lake Michigan lake trout and hatchery or wild Lake Nipigon male brook trout. Evaluation will be made through the regular creel census and experimental gear. The goal of this project is to create a winter fishery for splake in the Marinette area. A similar fishery has been developed in Chequamegon Bay of Lake Superior.

# LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 321

## WISCONSIN DEPT. OF NAT. RESOURCES

Wisconsin - Wisconsin Dept. of Natural Resources, Madison  
Bureau of Fish Management

## STOCK LAKE TROUT AND EVALUATE

Starting date:

Completion date: Continuing

Project no:

Sponsor: Wisconsin Dept. of Natural Resources

AREA: Lake Michigan; Wind Point Shoal; Black Can Reef;  
Northeast Reef; Sheboygan Reef; Northern Lake Michigan

## KEYWORDS:

management, biology, lake trout, fish, stocking,  
spawning, survival, reefs, movement, distribution,  
fish strains, rehabilitation, growth

## DESCRIPTION:

This project will stock lake trout in southern and northern Lake Michigan. In southern Lake Michigan, approximately 500,000 lake trout will be stocked annually and survival evaluated by spawning. Stocking and assessment activities will take place on Wind Point Shoal, Black Can Reef, Northeast Reef, and Sheboygan Reef. The Domestic (Superior), Green Lake, Seneca Lake and Jenny Lake strains will be evaluated to determine which species should be stocked. Movement and association to stocking location of planted lake trout will be determined.

In northern Lake Michigan, 100 to 200 thousand lake trout of different strains will be stocked on historic spawning reefs. Survivability, movement, growth rates, and reproduction will be compared among strains. Assessment data will be obtained through the monitoring of commercial and sport fisheries and by assessment fishing by WDNR. This project will contribute to the reestablishment of lake trout and identify lake trout strains that are best for stocking in Lake Michigan.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 322

WISCONSIN DEPT. OF NAT. RESOURCES

Wisconsin - Wisconsin Dept. of Natural Resources, Madison  
Bureau of Fish Management

LAKE MICHIGAN SALMONID CREEL CENSUS

Starting date:

Completion date: Continuing

Project no:

Sponsor: Wisconsin Dept. of Natural Resources

AREA: Lake Michigan

KEYWORDS:

recreation, biology, creel census, sport fishing, salmonid,  
lake trout, rainbow trout, brown trout, coho salmon,  
chinook salmon, salmon, trout, fish, management, stocking

DESCRIPTION:

This project will evaluate the stocking of trout and salmon in terms of return to anglers. Total harvest, total effort, catch per effort, species composition of catch, and geographical distribution of catch will be estimated. This project provides essential feedback concerning the current stocking program and will suggest program alterations to maximize stocking effectiveness.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 323

WISCONSIN DEPT. OF NAT. RESOURCES

Wisconsin - Dept. of Natural Resources, Madison  
Bureau of Water Resources Management

WATER POLLUTION ABATEMENT

Starting date:

Completion date: Continuing

Project no:

Sponsor: Wisconsin Dept. of Natural Resources

AREA: Lake Michigan; Sheboygan Harbor; Green Bay; Milwaukee  
River

KEYWORDS:

pollutants, chemistry, water quality, abatement,  
toxics, organics, wetlands, tributaries

DESCRIPTION:

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 324

WISCONSIN DEPT. OF NAT. RESOURCES;

U.S. ARMY CORPS OF ENGINEERS

Wisconsin - Dept. of Natural Resources, Madison;

Wisconsin - U.S. Army Corps of Engineers

IN-PLACE POLLUTANTS IN SHEBOYGAN HARBOR

Starting date: 1985

Completion date: 1986

Project no:

Sponsor: U.S. EPA - Great Lakes National Program Office

AREA: Sheboygan Harbor, Lake Michigan

KEYWORDS:

chemistry, pollution, dredging, sediments,  
organics, PCBs, water quality, fate, toxics

DESCRIPTION:

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 325

WONG, L.; MCCORQUODALE, J.A; SANDERSON, M.E.  
Ontario - University of Windsor, Windsor  
Great Lakes Institute

FUTURE CHANGES IN GREAT LAKES WATER BUDGET

Starting date:  
Completion date: Continuing  
Project no:  
Sponsor: Sponsor Not Known

AREA: Great Lakes

KEYWORDS:

model, hydrology, tributaries, runoff, lake levels,  
water budget, water supply, climate, historical,  
evaporation, precipitation

DESCRIPTION:

This project is using a modelling approach to assess the impacts of future climatic change on Great Lakes water supply. Two climatic change scenarios based on prediction from models developed by the Goddard Institute of Space Studies and the Geophysical Fluid Dynamics Lab were adopted. These climatic change scenarios were compared with a base case of historic climatic conditions. All major water supply parameters including basin runoff, overlake precipitation, and overlake evaporation were included in the model simulation. The heart of the model is a basin runoff model developed by GLERL/NOAA. Results of the net basin supply simulation indicated that under the two climate scenarios, total net basin supply of the Great Lakes could be reduced by more than 20%.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 326

WOOD, W.; DAVIS, S.

Indiana - Purdue University, West Lafayette  
Great Lakes Coastal Research Laboratory

INDIANA DUNES NATIONAL LAKESHORE SHORELINE  
SITUATION STUDY

Starting date: 9/1983

Completion date: 9/1986

Project no:

Sponsor: Indiana Dunes National Lakeshore

AREA: Southern Lake Michigan; Indiana Dunes National Lakeshore

KEYWORDS:

geology, erosion, sand dunes, littoral drift, vegetation,  
coastal structures, beach, beach nourishment, historical,  
bluffs, aerial photography, lake levels, hydrography,  
model, recession, waves, physical, currents, sediments

DESCRIPTION:

This project assessed the shoreline and adjacent nearshore area within the Indiana Dunes National Lakeshore with respect to coastal processes as they relate to historic and contemporary erosion. Particular attention was given to position changes of the shoreline, bluff top, nearshore sand bars, and dune vegetation. Beach and nearshore sediments were analyzed with respect to their contemporary grain properties and compared to historic data to determine areas of change. Another important aspect of the study dealt with man-made structures on the coast and their impact on overall coastal stability.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 327

WOOD, W.; DAVIS, S.

Indiana - Purdue University, West Lafayette  
Great Lakes Coastal Research Laboratory

STATE OF INDIANA SHORELINE SITUATION OVERVIEW

Starting date: 6/1986

Completion date: 11/1986

Project no:

Sponsor: State of Indiana

AREA: Southern Lake Michigan; Indiana shoreline

KEYWORDS:

geology, erosion, sand dunes, littoral drift,  
hydrography, aerial photography, beach, bluffs,  
coastal structures, model, lake levels,  
waves, currents, physical, sediments

DESCRIPTION:

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 328

ZABIK, M.J.

Michigan - Michigan State University, East Lansing  
Pesticide Research Center

STUDIES ON THE COMPOSITION AND PHOTOCHEMISTRY OF THE  
POLYCHLORINATED COMPONENTS OF TOXAPHENE IN THE GREAT LAKES

Starting date: 5/01/1983

Completion date: 1/31/1986

Project no: R/TS-25

Sponsor: Michigan Sea Grant College Program

AREA: Great Lakes

KEYWORDS:

analytical methods, toxaphene, photochemistry,  
chemistry, organics, water quality, atmospheric,  
sediments, biology, fate, rain, sunlight, irradiance,  
toxics, water quality, analytical methods,  
organochlorine pesticides

DESCRIPTION:

Objectives:

Validate and improve the analytical procedures for toxaphene residues in water, air, sediments and biological tissues from the Great Lakes. Initiate the photochemical fate of the major toxic components (B,A1,A2,Ac) of toxaphene in air, rain water and waters of the Great Lakes.

Benefits:

These studies will give those researchers in the physical and biological areas a knowledge of the exact composition of toxaphene entering the Great Lakes, methods for analysis of toxaphene at various levels of resolution and cost and how sunlight affects the overall composition as well as the specific isomers of toxaphene.



LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 329

See LYON, J. on page 239.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 330

See BRADEN, J.; HERRICKS, E. on page 56.

LAKE MICHIGAN PROJECTS - 1984-CONTINUING

Ref. no. 331

See DAVENPORT, R.; SPACIE, A. on page 103.

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COHO SALMON (SA: salmonid) .....	6,	60,	117,	124,	155,
	167,	168,	212,	213,	263,
	264,	317,	322		
COMMERCIAL FISHING .....	35,	36,	54,	75,	76,
	134,	141,	172,	223,	260,
	297,	319			
COMMON TERNS (SA: birds; SA: terns) ....	200				
COMPETITION .....	52,	85,	174,	204,	205,
	246,	293,	294		
CONNECTING CHANNELS .....	242,	244,	329		
CONSUMPTIVE USE (S: water use)					
CONTAMINANTS .....	8,	9,	11,	12,	20,
(SA: organics)	21,	22,	26,	49,	64,
(SA: specific compounds)	87,	88,	89,	91,	94,
	102,	121,	122,	123,	130,
	143,	144,	154,	159,	201,
	202,	211,	216,	235,	236,
	248,	250,	253,	254,	256,
	259,	283,	284,	285,	286,
	289,	303,	308,	311,	312,
	313				
COPEPODA (SA: zooplankton) .....	44,	85,	307		
COPPER .....	15,	257			
CORING (S: sediment cores)					
CORMORANTS (SA: birds).....	200,	312			
CRAYFISH .....	154,	246			
CREEL CENSUS .....	124,	141,	322		
CURRENTS (SA: circulation) .....	24,	69,	83,	163,	188,
	189,	190,	216,	218,	225,
	265,	266,	277,	278,	297,
	326,	327			
CYANOPHYTA (S: blue-green algae)					
CYCLING_INORGANICS .....	14,	15,	55,	71,	104,
	105,	112,	114,	132,	176,
	178,	231,	234,	240,	241,
	271,	272,	291,	292,	301,
	306				
CYCLING_METALS .....	14,	15,	176,	234,	301
CYCLING_NUTRIENTS .....	14,	15,	55,	71,	104,
	105,	112,	114,	132,	176,
	178,	179,	231,	234,	240,
	241,	271,	272,	291,	292,
	306				

	<u>Ref. no.:</u>				
CYCLING_ORGANICS .....	89, 249	92,	103,	179,	216,
CYCLING_TRACE METALS .....	14,	15,	176,	234,	301
DAMSELFLIES .....	131				
DATABASE .....	80, 248,	145, 283	146,	222,	245,
DATING (SA: carbon-14; SA: lead-210) ...	61, 275,	94, 281	100,	109,	129
DDD (SA: organochlorine pesticides) ....	64				
DDE (SA: organochlorine pesticides) ....	102,	159,	311		
DDT (SA: organochlorine pesticides) ....	22, 183,	27, 216,	100, 249,	143, 286,	159, 311
DECAY .....	24				
DECOMPOSITION .....	216,	240			
DEFORMITY .....	200,	312			
DEGRADATION .....	220,	254,	256		
DEPOSITION .....	73, 227, 301,	79, 254, 313	100, 255,	101, 258,	160, 273,
DEPURATION .....	181,	184,	236		
DESORPTION (SA: sorption) .....	87,	88,	298		
DETRITUS .....	116,	132,	164,	208	
DIAGENESIS .....	92,	100,	176,	234,	258
DIATOMS (SA: phytoplankton) .....	58,	71,	73,	173,	273
DIBENZO-P-DIOXINS (SA: dioxins) .....	122,	235,	236		
(SA: PCDD; SA: TCDD)					
DIBENZOFURANS (SA: furans; SA: PCDF) ...	22,	122,	236,	286	
(SA: TCDF)					
DIELDRIN .....	49,	64,	143,	249,	311
(SA: organochlorine pesticides)					
DIET (SA: fish_diet; .....	2,	3,	5,	6,	29,
(SA: invertebrate_diet)	31, 52, 91, 118, 165, 170, 196, 205, 263, 310,	32, 60, 102, 133, 166, 171, 197, 213, 264, 316	34, 64, 113, 135, 167, 174, 201, 214, 297,	44, 77, 114, 155, 168, 182, 203, 240, 306,	47, 85, 116, 159, 169, 184, 204, 251, 307,

	<u>Ref. no.:</u>				
DIFFUSION .....	24,	61,	216,	298	
DIOXINS (SA: specific compounds) .....	10,	12,	22,	122,	130,
	235,	236,	248,	285,	286
DISCHARGE .....	19,	83,	154,	289,	304
DISSOLVED OXYGEN (SA: oxygen) .....	18,	161,	234,	241	
DIVERSION .....	82,	156,	157,	242	
DREDGING .....	175,	202,	324		
DUCKS .....	84				
DUCKWEED .....	308				
ECONOMICS .....	1,	35,	36,	37,	59,
	108,	110,	139,	156,	157,
	172,	206,	210,	219,	221,
	232,	274,	288,	290,	330
EGGS (SA: fish_eggs) .....	51,	64,	122,	130,	144,
	147,	149,	150,	201,	235,
	296,	297,	311,	317	
ENDRIN (SA: organochlorine pesticides)..	311				
ENERGY FLOW .....	55,	113,	116,	195,	203
ENGINEERING .....	96,	221			
EROSION .....	67,	68,	79,	175,	326,
	327				
ESTUARY (S: wetlands)					
EUTROPHICATION .....	26,	93,	108,	173,	180,
	186,	192,	193,	207,	208,
	209,	251,	273		
EVAPORATION .....	80,	81,	82,	215,	217,
	325				
FATE (of pollutants or nutrients).....	9,	10,	12,	13,	14,
	49,	89,	92,	94,	103,
	123,	289,	298,	324,	328
FATHEAD MINNOW .....	95,	191,	263		
FATTY ACIDS .....	220				
FECAL PELLETS .....	240				
FECUNDITY (SA: reproduction) .....	200,	214,	246		
FEEDING (SA: predation) .....	32,	85,	240,	307,	314
(SA: zooplankton grazing)					
FISHING (S: commercial fishing)					
(S: sport fishing)					
FISH_ABUNDANCE .....	90,	125,	230,	296,	297,
	310,	319			

	<u>Ref. no.:</u>				
FISH_AGE .....	34, 318,	74, 319	77,	158,	214,
FISH_BEHAVIOR .....	32,	49,	150,	263	
FISH_BIOENERGETICS .....	29, 170,	49, 171,	167, 174,	168, 178	169,
FISH_DIET .....	2, 31, 60, 135, 167, 174, 204, 263,	3, 32, 77, 155, 168, 196, 205, 264,	5, 34, 102, 159, 169, 197, 213, 297,	6, 47, 118, 165, 170, 201, 214, 310,	29, 52, 133, 166, 171, 203, 251, 316
FISH_DISTRIBUTION .....	118, 205, 319,	125, 279, 321	195, 310,	196, 316,	197, 318,
FISH_EGGS .....	51, 150, 317	122, 201,	144, 235,	147, 296,	149, 297,
FISH_GENETICS .....	3, 320,	117, 331	140,	238,	239,
FISH_GROWTH .....	3, 34, 77, 144, 197, 297, 321	29, 47, 117, 158, 205, 310,	31, 49, 118, 170, 214, 316,	32, 52, 125, 171, 223, 318,	33, 76, 133, 191, 261, 319,
FISH_HABITAT .....	56, 158, 296,	70, 164, 316,	97, 205, 330	133, 208,	147, 263,
FISH_LARVAL .....	29, 118, 158, 235,	32, 144, 164,	34, 147, 169,	51, 149, 196,	52, 150, 197,
FISH_LIFE HISTORY .....	31, 296,	90, 297	149,	158,	204,
FISH_MANAGEMENT .....	1, 54, 133, 167, 284, 315, 321,	35, 75, 134, 171, 286, 316, 322,	36, 98, 135, 172, 290, 318, 330	47, 99, 146, 223, 297, 319,	48, 124, 154, 237, 310, 320,
FISH_MORTALITY .....	34, 90, 199, 319	51, 122, 201,	74, 133, 223,	75, 141, 260,	76, 144, 310,

	<u>Ref. no.:</u>				
FISH_MOVEMENT .....	74, 319,	118, 321	197,	279,	316,
FISH_PHYSIOLOGY .....	4, 33,	22, 38,	28, 159,	29, 236	30,
FISH_POPULATIONS .....	54, 90, 133, 169, 196, 214, 296,	60, 98, 134, 170, 197, 223, 297,	74, 99, 135, 171, 203, 230, 310,	76, 118, 165, 194, 204, 238, 319	77, 125, 168, 195, 205, 247,
FISH_PREDATION .....	32, 135, 168, 174, 251,	34, 155, 169, 180, 263,	51, 165, 170, 204, 264	60, 166, 171, 205,	118, 167, 173, 230,
FISH_PRODUCTIVITY .....	99, 203	170,	195,	196,	197,
FISH_RECRUITMENT .....	32, 149, 297	34, 158,	74, 169,	76, 172,	118, 296,
FISH_REHABILITATION .....	35, 97, 199,	36, 133, 261,	47, 147, 321	48, 148,	70, 150,
FISH_REPRODUCTION .....	28, 142, 191, 310	30, 144, 195,	97, 148, 201,	122, 149, 235,	133, 150, 261,
FISH_SIZE .....	32, 264	125,	165,	203,	205,
FISH_SPAWNING .....	30, 142, 158, 317,	48, 147, 194, 319,	70, 148, 208, 321	97, 149, 279,	133, 150, 296,
FISH_STOCKING .....	54, 318,	90, 320,	133, 321,	315, 322	316,
FISH_STRAINS .....	133, 315,	149, 316,	238, 317,	239, 320,	261, 321
FISH_TOXICS .....	22, 103, 153, 201, 236, 289,	49, 122, 154, 202, 248, 303,	51, 143, 159, 211, 259, 330,	95, 144, 162, 212, 284, 331	102, 152, 191, 235, 286,
FISH_YEAR-CLASS STRENGTH .....	34, 296,	76, 297	173,	204,	205,
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FLOW .....	20, 116, 250,	21, 195, 296	50, 203,	55, 242,	113, 244,
FLUFF LAYER (SA: nepheloid layer) .....	234				
FLUX .....	8, 27, 94, 254,	11, 61, 100, 258,	13, 71, 104, 267	15, 72, 138,	23, 92, 253,
FLY ASH .....	95				
FOOD CHAIN .....	27, 92, 116, 173, 230, 306	49, 102, 131, 180, 251,	52, 103, 132, 182, 269,	64, 112, 164, 186, 271,	91, 113, 166, 203, 291,
FORAGE FISH .....	29, 165, 205,	34, 166, 213,	60, 168, 223,	135, 174, 263,	155, 204, 264
FORAGING RATES (S: feeding; S: predation) (S: zooplankton grazing)					
FOSSILS .....	119,	273			
FURANS .....	10, 285	122,	130,	235,	248,
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GEOCHEMISTRY .....	71, 233,	72, 234,	73, 249,	176, 273,	220, 302
GEOGRAPHY (S: mapping)					
GEOLOGY .....	7, 61, 67, 72, 119, 175, 275, 295,	20, 62, 68, 73, 126, 222, 280, 326,	21, 63, 69, 79, 127, 233, 281, 327	45, 65, 70, 97, 129, 234, 282,	46, 66, 71, 109, 160, 273, 283,
GEOPHYSICAL .....	7,	69,	126,	127,	295
GLACIAL .....	45, 129,	62, 275,	63, 281,	67, 282	109,
GREEN ALGAE .....	58,	120			
GROUNDWATER .....	7, 82,	20, 282,	21, 283,	65, 295,	66, 296

	<u>Ref. no.:</u>				
GROWTH (SA: fish_growth) .....	3,	16,	29,	31,	32,
	33,	34,	47,	49,	52,
	58,	76,	77,	106,	107,
	116,	117,	118,	121,	125,
	133,	144,	158,	163,	170,
	171,	191,	197,	205,	214,
	223,	261,	268,	270,	292,
	293,	294,	297,	308,	310,
	316,	318,	319,	321	
GULLS (SA: birds; SA: herring gulls) ...	64,	84,	311,	312	
HABITAT .....	56,	70,	97,	133,	147,
	158,	164,	205,	208,	246,
	263,	296,	316,	330	
HARBORS .....	22,	96,	304		
HCB (SA: organochlorine pesticides) ....	100				
HEAVY METALS (SA: inorganics) .....	67,	286			
(SA: metals)					
HEPTACHLOR EPOXIDE .....	311				
HERRING GULLS (SA: birds; SA: gulls) ...	64,	311,	312		
HETEROTROPHY .....	107,	269,	291		
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	62,	63,	67,	93,	94,
	98,	99,	100,	109,	119,
	129,	160,	173,	229,	243,
	254,	257,	258,	273,	275,
	281,	325,	326		
HORMONES .....	28,	30			
HUMAN CONSUMPTION .....	152,	153,	159,	284	
HUMAN HEALTH .....	12,	152,	153,	159,	284
HUMIC ACID .....	309				
HYALLELA (SA: Amphipoda) .....	191				
HYDROGRAPHY .....	66,	69,	70,	97,	280,
	326,	327			
HYDROLOGY .....	7,	20,	21,	50,	55,
	65,	66,	78,	80,	82,
	156,	185,	242,	243,	245,
	250,	282,	283,	295,	296,
	325				
ICE .....	16,	17,	39,	40,	41,
	50,	96,	128,	187,	217,
	242,	244,	287,	305	
IMPRINTING .....	148,	149,	150		
INORGANICS (SA: cycling_inorganics) ....	14,	15,	19,	23,	26,
	44,	53,	55,	58,	67,



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INORGANICS (continued) .....	71,	72,	73,	93,	94,
	95,	104,	105,	106,	108,
	111,	112,	114,	115,	132,
	143,	154,	159,	173,	176,
	177,	178,	180,	185,	186,
	190,	207,	209,	227,	231,
	234,	240,	241,	251,	252,
	254,	255,	256,	257,	258,
	259,	262,	267,	270,	271,
	272,	273,	282,	286,	291,
	292,	293,	294,	298,	299,
	301,	302,	306,	311	
INORGANICS_METALS .....	14,	15,	67,	94,	95,
	154,	176,	234,	252,	254,
	256,	257,	258,	259,	262,
	282,	286,	298,	299,	301,
	302,	311			
INORGANICS_NUTRIENTS .....	14,	15,	19,	23,	26,
	44,	53,	55,	58,	71,
	72,	73,	93,	104,	105,
	106,	108,	111,	112,	114,
	115,	132,	173,	176,	177,
	178,	180,	185,	186,	190,
	207,	209,	227,	231,	234,
	240,	241,	251,	255,	262,
	267,	270,	271,	272,	273,
	282,	291,	292,	293,	294,
	306				
INORGANICS_TRACE METALS .....	14,	15,	94,	176,	234,
	252,	254,	257,	258,	262,
	282,	298,	299,	301,	302
INSECTS .....	131,	191			
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INVERTEBRATES_ABUNDANCE .....	42,	131,	230,	231	
INVERTEBRATES_BENTHIC .....	40,	46,	49,	102,	103,
	113,	114,	115,	116,	121,
	176,	181,	182,	183,	184,
	203,	205,	228,	229,	230,
	231,	240,	241,	246,	255,
	271,	305,	314		
INVERTEBRATES_DIET .....	52,	102,	113,	114,	116,
	182,	184,	203,	205,	240,
	306				
INVERTEBRATES_DISTRIBUTION .....	181,	205,	228,	229	
INVERTEBRATES_POPULATIONS .....	40,	43,	116,	131,	203,
	205,	228,	229,	230,	231,
	246,	305			

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INVERTEBRATES_TOXICS .....	49, 181, 211,	102, 182, 256,	103, 183, 314	121, 184,	154, 191,
IRON .....	176,	257			
IRRADIANCE (SA: light; SA: sunlight) ..	41,	120,	328,	331	
LAKE LEVELS .....	55, 82, 217, 275, 327,	66, 109, 242, 280, 329	67, 119, 243, 281,	68, 129, 244, 325,	80, 157, 245, 326,
LAKE STAGES, HISTORICAL .....	63, 281	67,	109,	119,	129,
LAKE TROUT (SA: trout) .....	30, 48, 90, 124, 141, 148, 167, 208, 237, 260, 310,	35, 56, 95, 133, 142, 149, 168, 212, 238, 261, 320,	36, 60, 97, 134, 143, 150, 174, 213, 239, 264, 321,	38, 70, 103, 135, 146, 155, 199, 223, 247, 286, 322	47, 77, 122, 140, 147, 165, 201, 235, 248, 290,
LAKE TROUT REHABILITATION .....	35, 97, 199,	36, 133, 261,	47, 147, 321	48, 148,	70, 150,
LAMPREY (S: sea lamprey)					
LAND USE .....	193,	222,	283		
LARVAL FISH (S: fish_larval)					
LEAD .....	61,	159,	234,	257,	258
LEAD-210 (SA: dating) .....	15,	61,	94,	100,	138
LIFE HISTORY .....	31, 296,	90, 297	149,	158,	204,
LIGHT (SA: irradiance) .....	106,	107,	120,	251	
LIPIDS .....	64, 220,	102, 249	113,	114,	116,
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	<u>Ref. no.:</u>				
LOSS RATES .....	267,	268			
MACROBENTHOS (S: invertebrates_benthic)					
MACROPHYTES (SA: vegetation) .....	55,	131,	163,	164,	262
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MANAGEMENT_BIOLOGY .....	35,	47,	48,	54,	75,
	98,	99,	124,	133,	134,
	135,	146,	151,	154,	167,
	171,	172,	223,	224,	284,
	286,	290,	297,	310,	315,
	316,	318,	319,	320,	321,
	322				
MANAGEMENT_DATABASE .....	145,	146,	222		
MANAGEMENT_ECONOMICS .....	1,	35,	36,	59,	108,
	156,	157,	172,	210,	232,
	290,	330			
MANAGEMENT_FISH .....	1,	35,	36,	47,	48,
	54,	75,	98,	99,	124,
	133,	134,	135,	146,	154,
	167,	171,	172,	223,	237,
	284,	286,	290,	297,	310,
	315,	316,	318,	319,	320,
	321,	322,	330		
MANAGEMENT_GEOLOGY .....	222				
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MANAGEMENT_RECREATION .....	1,	124,	232,	237,	322
MANAGEMENT_WATER_QUALITY .....	26,	82,	108,	154,	156,
	177,	192,	284,	286	
MANAGEMENT_WATER_SUPPLY .....	243				
MANAGEMENT_WATER_USE .....	50,	82,	156,	157,	243
MANGANESE .....	176,	257			
MAPPING .....	46,	66,	68,	70,	97,
	126,	127,	151,	192,	193,
	222,	280,	283,	295	
MARINAS .....	96,	139			
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MASS BALANCE .....	27,	302			
MAYFLY .....	191				

	<u>Ref. no.:</u>				
MERCURY .....	234,	257,	258,	311	
METALS (SA: cycling_metals) .....	14,	15,	67,	94,	95,
	154,	176,	234,	252,	254,
	256,	257,	258,	259,	262,
	282,	286,	298,	299,	301,
	302,	311			
METEOROLOGY .....	17,	50,	78,	80,	81,
	187,	215,	217,	227,	299
MICROBIOLOGY (SA: bacteria) .....	42,	291			
MINERALIZATION .....	115				
MIREX (SA: organochlorine pesticides) ..	64,	100,	311		
MIXING .....	15,	94,	176,	215,	233,
	254,	255,	258,	272,	301,
	314				
MODEL .....	9,	10,	11,	16,	17,
	20,	21,	23,	24,	25,
	26,	27,	35,	45,	49,
	50,	56,	61,	64,	66,
	71,	72,	74,	76,	78,
	79,	80,	82,	83,	86,
	89,	96,	103,	108,	123,
	128,	135,	138,	156,	157,
	167,	168,	169,	170,	171,
	172,	173,	174,	176,	178,
	181,	183,	198,	203,	206,
	212,	215,	216,	217,	222,
	225,	233,	234,	242,	243,
	244,	245,	252,	253,	254,
	255,	266,	270,	271,	276,
	277,	278,	282,	284,	287,
	288,	293,	295,	296,	297,
	298,	301,	302,	304,	309,
	325,	326,	327,	330	
MODELING (S: model)					
MOLYBDENUM .....	257				
MONITORING .....	9,	22,	53,	90,	93,
	141,	142,	143,	154,	161,
	192,	194,	199,	200,	207,
	214,	223,	224,	227,	247,
	260,	261,	279,	286,	289,
	310,	311			
MORTALITY (SA: fish_mortality) .....	34,	51,	74,	75,	76,
	90,	122,	133,	141,	144,
	199,	201,	223,	260,	310,
	319				
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(SA: benthic boundary layer)					
NEUSTON .....	34				
NICKEL .....	257				
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NONPOINT SOURCE .....	26,	79,	154,	283,	330
NORTHERN PIKE .....	259,	319			
NUTRIENTS (SA: specific nutrients) .....	14,	15,	19,	23,	26,
(SA: cycling_nutrients)	44,	53,	55,	58,	71,
(SA: eutrophication)	72,	73,	93,	104,	105,
(SA: uptake_nutrients)	106,	108,	111,	112,	114,
	115,	132,	173,	176,	177,
	178,	179,	180,	185,	186,
	190,	207,	209,	227,	231,
	234,	240,	241,	251,	255,
	262,	267,	270,	271,	272,
	273,	282,	291,	292,	293,
	294,	306			
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(SA: uptake_organics)	27,	49,	51,	61,	64,
	86,	87,	88,	89,	91,
	92,	100,	101,	102,	103,
	120,	121,	122,	123,	130,
	143,	144,	152,	153,	154,
	159,	179,	181,	182,	183,
	184,	191,	200,	201,	202,
	211,	212,	216,	220,	227,
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	168,	169,	171,	172,	205,
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(SA: organochlorine pesticides)	100,	102,	103,	143,	159,
	183,	200,	211,	212,	216,
	249,	259,	286,	311,	314,
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	95,	102,	103,	104,	105,
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	164,	173,	179,	180,	186,
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	155,	162,	165,	167,	168,
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	169,	171,	172,	205,	223,
	236,	263,	264,	310,	319
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## **ACKNOWLEDGEMENTS**

Funding for this project was provided by The Joyce Foundation and the Illinois Department of Energy and Natural Resources. I wish to thank Steve Jann, Beth Morgan, Joanne Klitzing and Kathy Cooley for their work on final preparation of this inventory. I also wish to thank Charles Collinson (ISGS), Robert Gorden (INHS), Donald Gatz (ISWS), and Peter Lamb (ISWS) for their input on the initial three-Survey Lake Michigan Scoping Study sponsored by the Illinois Department of Energy and Natural Resources, Board of Natural Resources and Conservation.

















